ISPARTA UYGULAMALI BİLİMLER ÜNİVERSİTESİ

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Evaluation of various properties of gypsum particleboards reinforced with olivine mineral

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Abstract: In this study, it was investigated some properties of gypsum particleboards which is produced with olivine mineral. Wood particles were added as reinforcement in different proportions (70% and 30%) to two types of plasterboard. The effects of inorganic olivine mineral added to these two types of boards were evaluated in terms of their physical and mechanical properties, thermal conductivity, and combustion behaviour. Subsequently, tests were carried to determine their water absorption, thickness swelling, internal bonding, bending strength, modulus of elasticity, thermal conductivity, and combustion performance. The properties of the boards were then examined using Fourier-transform infrared spectroscopy and thermogravimetric analysis. The Fourier-transform infrared analysis revealed the typical traces of cellulose, hemicellulose, and lignin in the wood material, traces of gypsum as the binder, and varying traces of olivine, according to the additive ratio, were also observed. Thermal analysis determined the positive contribution of olivine to the basic stability of both types of boards. It can be concluded that olivine, when added in different proportions, is a suitable reinforcement material for improving the technical properties of gypsum particleboard.
Keywords: Gypsum particleboard, Olivine, Physical properties, Mechanical properties, Thermal conductivity, Combustion

Olivin minerali ile güçlendirilmiş alçılı yonga levhaların çeşitli özelliklerinin değerlendirilmesi

Özet: . Bu çalışmada, olivin minerali ile üretilen alçılı yonga levhaların bazı özellikleri araştırılmıştır. İki farklı oranda alçı (%70 ve %30) eklenerek oluşturulan levhalara farklı oranlarda odun yongaları eklenmiştir. Bu iki tip levhaya ilave edilen inorganik olivin mineralinin, levhanın fiziksel özellikleri, mekanik özellikleri, ısıl iletkenlik ve yanma davranışlarına olan etkileri değerlendirilmiştir. Üretilen levhaların su alma, kalınlığına şişme, çekme direnci, eğilme direnci, elastikiyet modülü, termal iletkenlik ve yanma performansını belirlemek için testler yapılmıştır. FTIR analizi, ahşap malzemede selüloz, hemiselüloz ve lignin varlığını, bağlayıcı olarak alçının ve katkı oranına göre değişen olivinin varlığını ortaya koymaktadır. Termal analiz ile olivin'in her iki tip levhanın stabilitesine olumlu etkisi olduğu belirlenmiştir. Olivin, farklı oranlarda eklendiğinde, alçılı yonga levhanın bazı özelliklerini geliştirmek için uygun bir takviye malzemesi olduğu sonucuna varılabilir
Anahtar kelimeler: Alçılı yonga levha, Olivine, Fiziksel özellikler, Mekanik özellikler, Termal iletkenlik, Yanma

1. Introduction

Gypsum is a mineral used to produce gypsum board (Ahmad et al., 2017). Gypsum board is widely used as a finishing material for structural applications to improve the indoor air comfort level, provide thermal insulation, provide protection against fire, and provide some lateral support (Espinoza-Herrera and Cloutier, 2009; Park et al., 2019).

However, gypsum particleboard (GPB) is an inorganic-bonded panel constructed by combining wood particles using gypsum as an adhesive. It is primarily used for residential construction, e.g., wall and roof sheathing (Espinoza-Herrera and Cloutier, 2011). In comparison with gypsum board, GPB exhibits lower friability, as it does not chip, crumble, or break easily when compressed (Deng et al., 1998; Ahmad et al., 2017).

Another reason that these products with mineral bonds have attracted attention in the building industry is that they do not emit formaldehyde (Mendes et al., 2011). In addition, the gypsum and binder protect the wood particles against fire (Tichi et al., 2016).

Recently, eco-friendly materials have begun to play an important role in the building materials market. Hemp, short cellulose, sisal, palm, and straw fibers are being used for plaster/gypsum reinforcement (Iucolano et al., 2018). In order to improve the properties of GPB, some studies have proposed the addition of reinforcing materials (Espinoza-Herrera and Cloutier, 2011). Deng and Furuno (2001) added polypropylene (PP) fibers, jute fibers, and coconut fibers to GPB.

Therefore, a considerable amount of research has been carried out in which additives have been used to enhance the mechanical and physical properties of gypsum boards (Barbero-Barrera et al., 2017). The addition of mineral fillers in the form of tiny particles leads to the separation of the flammable material (the lignocellulosic particles present in the board) and a subsequent decrease in the thermal conductivity, which gives the board fire-resistant properties.

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The most common inorganic materials used as mineral fillers are vermiculite and perlite. By covering and penetrating the lignocellulosic particles, mineral binders are responsible for the addition of their fire-retardant properties (Kozlowski et al., 1999).

Olivine is derived from the Latin word oliva (olive), due to its olive-green color. Olivine is a very bright mineral variety that is resistant to high temperatures, belongs to the silicate mineral group, and contains Mg and Fe ions. However, its color can vary from black to green (Yalçın, 2018). It is a refractory material that is resistant to high melting temperature (1890 °C) and shows zero shrinkage against temperature. However, its low heat dissipation makes it suitable for thermal insulation materials (Shi et al., 2010). Today, olivine mineral is seen as a mineral substance with expanding usage areas. Initially, it was utilized to provide heat and sound insulation and due to its abrasive quality, for blast-cleaning buildings (Yalçın, 2018). According to Hu et al. (2006), they found that adding olivine to epoxidized natural rubber composites can improve their mechanical and dynamic mechanical properties. Ismail et al. (2005) reported that the excellent rheological and dynamic properties of composites composed of olivine filled paper fibers demonstrated a positive effect.

This study used mineral olivine material and red pinewood chips for GPB production and investigated the thickness swelling (TS), water absorption (WA), modulus of elasticity (MOE), modulus of rupture (MOR), thermal conductivity, flame combustion, internal bond (IB) values, thermal properties, and chemical properties of olivine-based GPB samples.

2. Material and method

The olivine mineral material was collected from Isparta-Aksu mining sites in Turkey. The commercial gypsum was purchased from a company in Isparta, Turkey. The boards were made from gypsum, olivine mineral, and red pinewood particles (0.5 mm to 0.8 mm) at a moisture content of 10%. The gypsum, wood, and olivine mineral were mixed in different proportions. The mats were formed in wet molds with dimensions of 40 cm x 40 cm x 1 cm and pressed at a temperature of 20 °C to 24 °C under a pressure of 1.5 MPa to 2 MPa for 5 min. Thirty samples were prepared for evaluation of physical and mechanical properties. Besides, five samples were prepared for each thermal tests. Before testing, the boards were conditioned by being placed between metal plates after the pressing process and acclimatized at a temperature of 23 °C and a relative humidity of 65% for three weeks. Cambering occurs in the middle part of the samples, due to the drying process of the board samples. In order to prevent this cambering, the boards stayed between the metal sheets while drying.

Water absorption was calculated according to Eq. 1,

$$WA = \frac{W_2 - W_1}{W_1} \times 100 \tag{1}$$

Where WA is the water absorption amount (%), w_1 is the weight (g) of test specimen before being soaked in water, and w_2 is the weight (g) of test specimen after being soaked in water.

Thickness swelling was calculated according to Eq. 2,

$$TS = \frac{T_2 - T_1}{T_1} \times 100 \tag{2}$$

where TS is the thickness swelling (%), t_2 is the thickness of the water-soaked specimen after 2 h and 24 h (mm), and t_1 is the thickness of the conditioned specimen before being soaked in water (mm).

The gypsum-olivine board specimens were soaked in water for 2 h and 24 h at a temperature of 20 °C and then measured in order to determine thickness swelling (TS) and water absorption (WA) according to ASTM standard D1037 (1999). The internal bond (IB), modulus of elasticity (MOE), and modulus of rupture (MOR) of the boards were determined (%) in accordance with EN standard 310 (1993) and EN standard 319 (1999).

The thermal conductivity of the test samples was examined in compliance with the ASTM standard C1113-90 (1990) *via* the hot-wire method using a QTM 500 device. A standard flame combustion test system was applied according to ISO standard 11925-2 (2010). A Shimadzu IR Prestige-21 Fourier-transform infrared (FTIR) spectrophotometer was used to analyze the compounds related to the surface. Thermogravimetric analysis (TGA) was performed using a Seiko SII TG / DTA 7200 instrument in a nitrogen atmosphere, and samples were heated to a temperature of 20 °C to 900 °C at a heating rate of 10 °C / min. The ratios (%) of olivine, wood, and gypsum in the various board types are shown in Table 1 along with the codes given to the experimental sample boards in this study. Measurements were conducted in the Forest Product Engineering Research and Application Laboratory at the Isparta University of Applied Sciences.

3. Results and discussion

3.1. Physical properties

The mineral-based GPB was produced by adding appropriate amounts of gypsum, wood, and olivine. Table 2 shows the WA (%) and TS (%) values of the boards after the specimens were soaked in water for 2 h and 24 h. Gypsum and wood are known to have a high tendency to absorb water compared to olivine. For this reason, the TS and WA values were markedly reduced by the olivine mineral content.

Table 1. Code numbers and mixture proportions (%)

Board codes	Type 1				Type 2			
	Ol_1	Ol_2	Ol_3	GP-1	Ol_5	Ol_6	Ol_7	GP-2
Ingredients								
Olivine (%)	24	18	12	0	24	18	12	0
Red pinewood (%)	6	12	18	30	46	52	58	70
Gypsum (%)	70	70	70	70	30	30	30	30

Ol: The board code indicates that different ratios (%) of olivine, wood, and gypsum which used for board samples, GP: Control samples for each type of board samples.

As observed in Table 2, increasing the amount of gypsum and wood in the mixture caused the TS and WA of the boards to increase because the gypsum and wood particles easily absorbed water. In fact, because of the reduction of gypsum, after immersion in water for 2 h and 24 h, the TS reduction ratios were 70% and 30%, respectively. However, the addition of red pinewood particles was responsible for the small increments.

The lowest TS value after 24 h was found in the Ol_5 board, which had the highest amount of olivine mineral among the boards. Moreover, the TS values of the experimental boards obtained after 2 h of immersion were generally higher than the TS values for gypsum particleboard (8%), gypsum fiberboard (3%), gypsum cardboard (3%), or gypsum flakeboard (2% to 5%) (Espinoza-Herrera and Cloutier, 2011). However, the presence of an increased amount of gypsum mineral had a negative effect on the TS and WA properties. Therefore, it would be appropriate to apply for interior usage where there would be less contact with water.

3.2. Mechanical properties

The IB properties of the boards according to the olivine rate are shown in Figure 1. The addition of olivine mineral to the boards resulted in better adhesion of the wood particles with the gypsum, therefore increasing the IB values. As shown in Figure 1, the IB value increments of the boards were correlated with the increasing levels of olivine mineral.

The 46% to 70% addition of wood particles to the 30% gypsum was found to more greatly impact the internal bond properties of the boards compared to the 6% to 30% addition of wood particles to the 70% gypsum. Thus, the rising proportion of wood particles in the mixture had a positive effect on the IB properties. This could be due to the mineral content in the board composition, which increased the gypsum absorption of the wood particles. For this reason, the usage of olivine mineral in the board composition increased the IB properties.

The bending strength properties of the boards produced with various olivine, gypsum, and wood particle contents are shown in Figure 2. The MOR increased as the gypsum/olivine content increased, whereas the MOE values of the boards decreased as the wood content increased. When the amount of gypsum/olivine increased, the density increased but the structure became fragile. Therefore, as the MOE values decreased, the MOR values increased. The highest MOR value (6.9 MPa) was found in the Ol_1 board, produced with 24% olivine, 6% red pinewood, and 70% gypsum. However, the highest MOE value (44.37 MPa) was observed in the GP-2 board, composed of 70% red pinewood and 30% gypsum.

The effects of the wood content on the MOE of the boards are illustrated in Figure 2. The MOE tended to slightly increase when the wood content was increased up to 70%. However, the mechanical properties of the boards could not meet the required standards for boards, *e.g.*, as construction boards. Therefore, they are only usable for indoor applications, insulation panels and sidings.

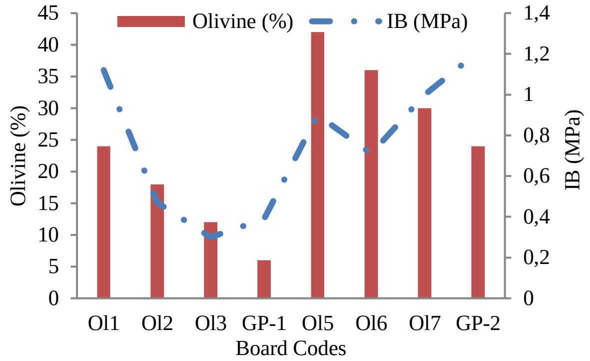

Figure 1. Internal bond (IB) properties of the boards depending on olivine rate

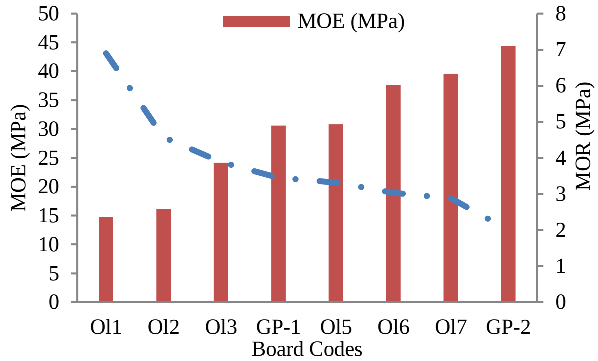

Figure 2. Modulus of rupture (MOR) and modulus of elasticity (MOE) properties of the boards

Table 2. Water Absorption (%) and Thickness Swelling (%) Values of Boards according to control group

Board Code	WA (2 h)	WA (24 h)	TS (2 h)	TS (24 h)
Ol_1	32.2	43.6 (1.29)B*	4.2	5.0 (0.42)A
Ol_2	50.7	54.4 (2.02)B	9.5	9.6 (1.16)A
Ol_3	44.2	47.1 (3.06)B	21.1	21.2 (1.14)C
GP-1	43.3	53.4 (1.39)B	25.9	26.1 (2.35)C
Ol_5	16.4	17.0 (0.72)A	0.3	0.4 (0.04)A
Ol_6	48.9	78.8 (1.51)D	0.1	0.5 (0,11)A
Ol_7	71.5	76.8 (1.80)D	16.9	18,0 (1.10)B
GP-2	77.7	86.5 (1.44)D	23.7	23.8 (1.21)B

*Values in parentheses represent the standard division and (A, B, C, D) denote homogeneous groups.

3.3. Thermal properties (Thermal conductivity, combustion, and thermogravimetry/differential thermal analysis)

The thermal conductivity and the density values obtained from the various types of boards prepared with gypsum as a binder are shown in Figure 3. The highest and lowest thermal conductivity values were 0.9808 w/mK and 0.2302 w/mK for the Ol_1 and Ol_5 boards, respectively. It was understood that these boards could not meet the 0.065 w/mK standard required for usage as a building and thermal insulation material (Yalçın, 2018). However, as the amount of gypsum in the mixture was increased, the thermal insulation property of the material decreased.

Figure 4 shows the results of the combustion experiments carried out with a single flame source. The dimensions of the prepared test samples were 100 mm x 100 mm. The thermal insulation values were recorded by measuring the back surface of the test boards with an infrared laser thermometer for a duration of 300 s. As seen in Figure 4, the highest surface temperature that passed to the side opposite of the flame source after 300 s was found in Ol_1, *i.e.*, 295.7 °C. However, the lowest value after 300 s was observed in the Ol_5 board, *i.e.*, 100 °C.

Detailed results of the thermogravimetric analysis (TGA) and the derivative thermogravimetric (DTG) curves are given in Figure 5 and Table 3 for the Type 1 samples and in Figure 6 and Table 4 for the Type 2 samples. Two types of GPB samples were prepared and the effects of olivine (12%, 18%, and 24% by weight) were investigated for thermal stability. When the DTG curves of both types of samples were examined, degradation was seen to take place in four phases. In the first phase (150 °C to 160 °C), a 5% to 10% mass loss was realized as a result of water loss in the lignocellulosic components and hydration in the plaster structure.

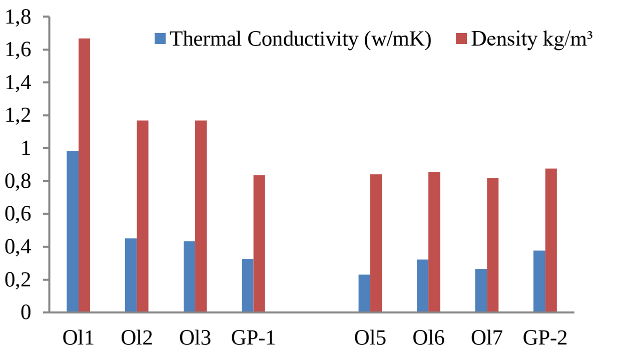

Figure 3. Comparison of the density(kg/m^3) and thermal conductivity(w/mK) values of the board samples

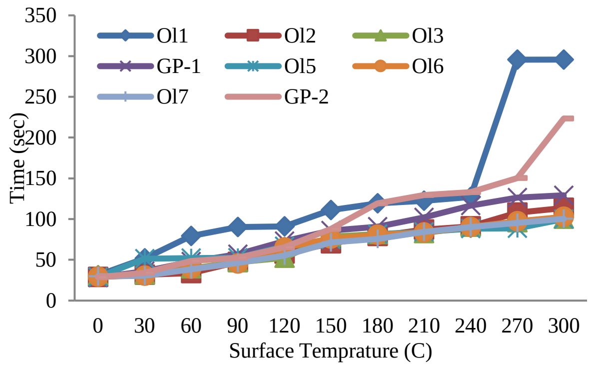

Figure 4. Surface temperature values of the combustion experiment

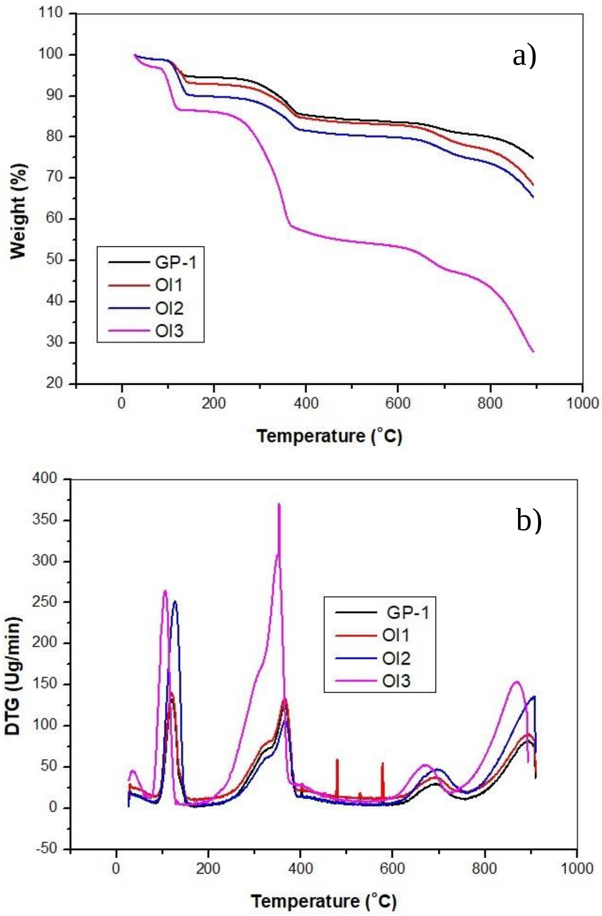

Figure 5. Type 1 boards (GP-1, Ol_1, Ol_2, and Ol3): a) Thermogravimetric analysis (TGA); and b) derivative thermogravimetric (DTG) curves

In the second phase (200 °C to 400 °C), the greatest loss of mass was observed. The temperature varied in this phase according to the ratio of the components in the structure of the wood. As a result of the degradation of hemicellulose, cellulose, and lignin, a mass loss of 20% to 40% occurred. The degradation of hemicellulose is known to occur at a temperature of 240 °C to 280 °C, the degradation of cellulose at 280 °C to 350 °C, and the degradation of lignin at 350 °C to 400 °C; Gao et al. (2006) reached a similar conclusion about the thermal behavior of black pine in their study. In the third and fourth phases, the gypsum maintained thermal stability and a thermally stable phase was formed. No mass loss was observed in the gypsum during this phase. However, at a temperature of 700 °C to 900 °C, mass loss occurred because of the carbonization of the organic compounds and the burning of the volatile components. This loss was measured in the olivine-augmented samples as 68.67%, 65.44%, and 27.91% in the Type 1 boards and 55.34%, 44.55%, and 26.42% in the Type 2 boards, respectively.

Table 3. Thermogravimetric Analysis-Derivative Thermogravimetric Data for Type 1 Boards (GP-1, Ol_1, Ol_2, and Ol_3)

	$T_{5\ wt.\%}$ (°C)	$T_{10\ wt.\%}$ (˚C)	$T_{50\ wt.\%}$ (˚C)	T_{1max} (˚C)	T_{2max} (˚C)	T_{3max} (˚C)	T_{4max} (˚C)	900 ˚C Residue (wt.%)
GP-1	135	340	-	165	385	702	865	74.89
Ol_1 GP-1	125	185	-	154	386	683	885	68.67
Ol_2 GP-1	120	178	-	150	387	685	880	65.44
Ol_3 GP-1	94	109	670	146	375	700	877	27.91

T_5 wt.%: thermal decomposition temperature at 5% weight loss; T_{10} wt%: thermal decomposition temperature at 10% weight loss; T_{50} wt%: thermal decomposition temperature at 50% weight loss; T_{1max}: the temperature of the peak maximum at the 1st degradation step (ºC); T_{2max}: the temperature of the peak maximum at the 2nd degradation step (ºC); T_{3max}: the temperature of the peak maximum at the 3rd degradation step (ºC); and T_{4max}: the temperature of the peak maximum at the 4th degradation step (ºC)

The thermal behavior of the GPB Type 1 boards (GP-1) is shown in Figure 5 and Table 3. The addition of olivine by 12%, 18%, and 24% increased thermal stability. According to the TGA results, T_5 (95 °C), T_{10} (109 °C), and T_{max} (877 °C) values were found for the Ol_3 samples. However, 125 °C, 185 °C, and 885 °C were observed for the Ol_1 samples, respectively. According to Table 3, when 24% olivine was added, the decomposition temperature was delayed. The mass loss for the Ol_3 samples was 27.91% and 68.67% for the Ol_1 samples. Hence, a thermally superior structure was obtained.

Figure 6 and Table 4 show that in the GPB Type 2 boards (GP-2), the addition of 12%, 18%, and 24% olivine by weight increased the thermal stability. According to the TGA results, T_5 (101 °C), T_{10} (273 °C), and T_{max} (856 °C) values were found for the Ol_7 samples. However, 115 °C, 293 °C, and 878 °C were observed in the Ol_5 samples, respectively. According to Table 4, with the addition of 24% olivine, the decomposition temperature was delayed. The mass loss was 26.42% for the Ol_7 samples and 55.34% for the Ol_5 samples. When the results were evaluated, excellent thermal stability was achieved in the Type 1 board samples when the wood contribution was limited to 18% and the olivine mineral contributions were 12% and 24%. Although the wood additive was 52% in the Type 2 boards, the superior thermal stability contribution of the olivine increased the thermal behavior of the sample, resulting in a superior thermally stable sample.

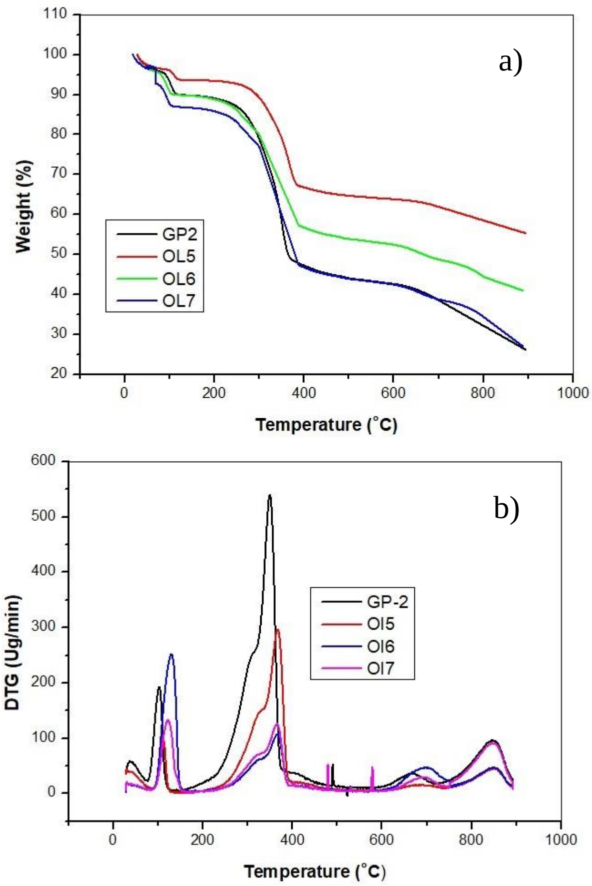

Figure 6. Type 2 boards (GP-2, Ol_5, Ol_6, Ol_7): a) Thermogravimetric analysis (TGA); and b) derivative thermogravimetric (DTG) curves

Table 4. Thermogravimetric Analysis-Derivative Thermogravimetric Data for Type 2 Boards (GP-2, Ol_5, Ol_6, Ol_7)

	$T_{5\ wt.\%}$ (°C)	$T_{10\ wt.\%}$ (˚C)	$T_{50\ wt.\%}$ (˚C)	T_{1max} (˚C)	T_{2max} (˚C)	T_{3max} (˚C)	T_{4max} (˚C)	900 ˚C Residue (wt.%)
GP-2	98	124	364	167	391	692	895	26.19
Ol_5 GP-2	115	293	-	155	385	-	878	55.34
Ol_6 GP-2	112	284	308	154	377	-	872	44.55
Ol_7 GP-2	101	273	289	151	368	-	856	26.42

T_5 wt.%: thermal decomposition temperature at 5% weight loss; T_{10} wt%: thermal decomposition temperature at 10% weight loss; T_{50} wt%: thermal decomposition temperature at 50% weight loss; T_{1max}: the temperature of the peak maximum at the 1st degradation step (ºC); T_{2max}: the temperature of the peak maximum at the 2nd degradation step (ºC); T_{3max}: the temperature of the peak maximum at the 3rd degradation step (ºC); and T_{4max}: the temperature of the peak maximum at the 4th degradation step (ºC)

3.4. Fourier-transform infrared (FTIR) Spectra

Two types of boards were produced, in which 30% and 70% by weight of gypsum was used as the binder. The FTIR spectra (as shown in Figure 7a and 7b) revealed typical traces of cellulose, hemicellulose, and lignin in the wood material, traces of gypsum as the binder, and varying traces of olivine, according to the additive ratio.

According to the FTIR spectra (as shown in Figure 7), the bands in the range of 3544 cm^{-1} to 3406 cm^{-1} are the vibrations of -OH α-cellulose and the strong tensile bond of gypsum (Kondo and Sawatari, 1996; Schwanninger et al., 2004; Prasad et al., 2005). The bands at 2800 cm^{-1} to 2964 cm^{-1} are linked to the -CH stretch bond vibration of the CH_2 and CH_3 groups. The CH and OH stresses are caused by the methyl and methylene group, hemicellulose, and cellulose (Kondo and Sawatari, 1996; Schwanninger et al., 2004). At 2000 cm^{-1} to 2150 cm^{-1}, the basic C-OH stress of cellulose is seen (Kondo and Sawatari, 1996; Pasquali and Herrera, 1997; Schwanninger et al., 2004). The 1700 cm^{-1} to 1730 cm^{-1} C-O stress is due to the carboxyl- and ester groups, unconjugated aldehyde acetic acid (Guo and Chen, 2004) and hemicellulose (Merk et al., 1997; Dubis et al., 1999; Singthong et al., 2004; Singthong et al., 2005). New absorption bands were observed at 2150 cm^{-1} to 1625 cm^{-1}, which were caused by the absorption of the -SiO4 group in the olivine, i.e., the strong band of silicates (Matveev and Stachel, 2007). At 1600 cm^{-1} to 1620 cm^{-1}, C=C deformation, C-C stress, and C=C aromatic symmetric stress were observed within the aromatic ring lignin-induced conjugated double bonds. Aromatic skeletal vibrations were affected by the aromatic C-O stretching mode at 1650 cm^{-1} and the conjugation with the carbonyl groups (Fengel, 1991). At 1510 cm^{-1}, lignin aromatic skeletal vibrations were seen (Akgül et al., 2007). The characteristic tensile band of the aromatic compounds is at 1450 cm^{-1} in wood and wood extractives (He and Hu, 2013).

The characteristic indicator of cellulose is -O-H bending at 1140 cm^{-1} to 1145 cm^{-1}, -CH bending at 380 cm^{-1} and 1375 cm^{-1} to 1365 cm^{-1}. However, C-O-C asymmetric stretching and C-O stretching of cellulose occur in the 1280 cm^{-1},1160 cm^{-1}, 1047 cm^{-1}, and 1004 cm^{-1} bands (Liang and Marchessault, 1959).

Hemicellulose-induced asymmetric stress, and at 1119 cm^{-1}, hemicellulose C-C, C-OH, C-H bond, and vibration of the side groups (hemicellulose) are seen (Fengel, 1991; Kondo and Sawatari, 1996; Oh et al., 2005).

At 875 cm^{-1} to 712 cm^{-1} there is C-O asymmetric vibration. (Grishechko et al., 2013; Falcão and Araújo, 2014). At 1119 cm^{-1}, 875 cm^{-1}, and 712 cm^{-1}, strong vibration bands were seen and at 1685 cm^{-1} and 669 cm^{-1}, medium strength vibration bands were seen, which are traces of the presence of gypsum ($CaSO_4 \cdot 2H_2O$) (Prasad et al., 2005). The 669 cm^{-1}, 603 cm^{-1}, and 463 cm^{-1} bands are vibration bands that indicate the presence of $Fe_2(SiO_4)$ and $Mg_2(SiO_4)$.

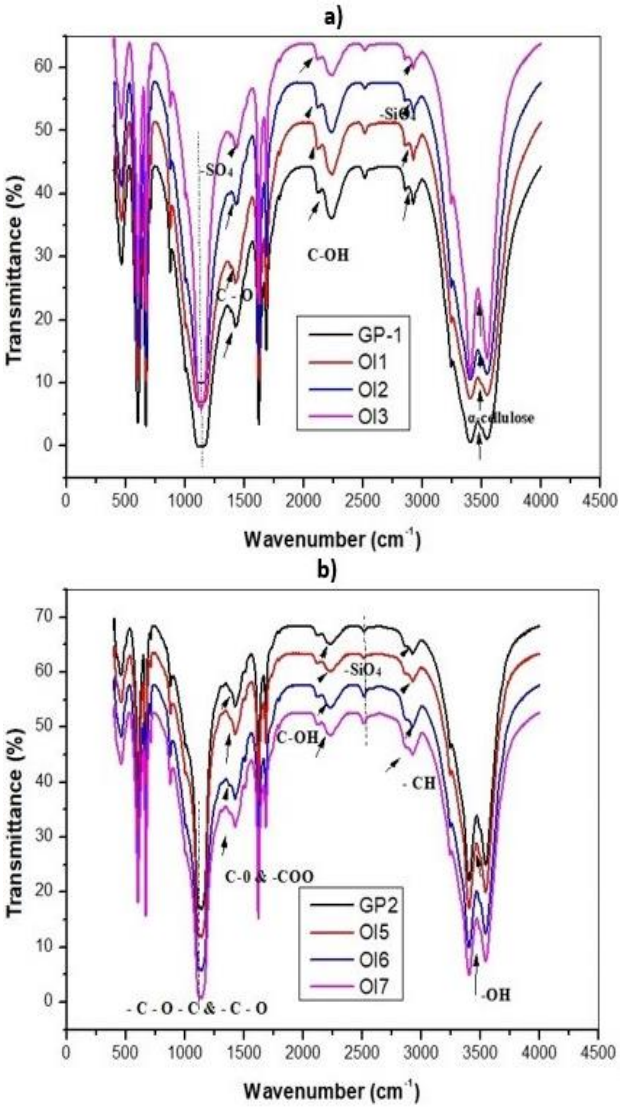

Figure 7. Comparative Fourier-transform infrared (FTIR) spectroscopy analyses: a) GP-1, Ol_1, Ol_2, Ol_3 boards; and b) GP-2, Ol_5, Ol_6, Ol_7 boards

4. Conclusion

In this study, mineral olivine material and red pinewood chips were used in GPB production. The thickness swelling (TS) and water absorption (WA) values were markedly reduced with addition of the olivine mineral. Increasing the amounts of the gypsum and wood in the mixture caused the TS and WA of the boards to increase.

The addition of olivine mineral to the boards led to increases in the IB values. In addition, the increasing proportion of wood particles in the mixture had a positive effect on the IB properties. However, increases of the gypsum/olivine content increased the MOR values. The MOE values decreased as the wood content of the boards increased.

The experimental board samples failed to achieve the 0.065 w/mK standard determined for building and thermal insulation material. However, when the amount of gypsum in the mixture was increased, the thermal insulation property of the material decreased.

Two types of gypsum particleboard samples were prepared and the effects on the thermal stability of olivine

(12%, 18%, and 24% by weight) were investigated. When the TGA curves of the samples of both types were examined, degradation was found to take place in four phases. When the results were evaluated, the wood contribution was limited at 18% in the Type 1 board samples; therefore, excellent thermal stability was achieved with olivine mineral additions of 12% and 24%. Although the wood content was 52% in the Type 2 boards, the superior thermal stability contribution of the olivine boosted the thermal behavior of the board, resulting in a superior thermally stable sample.

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