Sigma J Eng & Nat Sci 11 (2), 2020, 135-140

Publications Prepared for the Sigma Journal of Engineering and Natural Sciences
Publications Prepared for the ORENKO 2020 - International Forest Products Congress Special Issue was published by reviewing extended papers

Research Article

MECHANICAL PROPERTIES OF MYCELIUM BASED MDF

Engin Derya GEZER*[1], Esat GÜMÜŞKAYA[2], Ezel UÇAR[3], Derya USTAÖMER[4]

[1] *Karadeniz Technical University, Dept. of Forest Industry Eng., TRABZON;* ORCID:0000-0001-9657-7290
[2] *Karadeniz Technical University, Dept. of Forest Industry Eng., TRABZON;* ORCID:0000-0003-1892-7317
[3] *Karadeniz Technical University, Dept. of Forest Industry Eng., TRABZON;* ORCID:0000-0001-8588-5765
[4] *Karadeniz Technical University, Dept. of Forest Industry Eng., TRABZON;* ORCID:0000-0003-0102-818X

Received: 28.11.2020 Accepted: 04.12.2020

ABSTRACT

Mycelium composites have been popular recently worldwide in terms of research interest and commercialization. Mycelium composites are biodegradable, produced renewable materials, environmentally friendly and show low density, good insulation properties, both related to acoustic and thermal aspects. However, mechanical properties of mycelium composites are obviously lower than alternative materials such as expanded polystyrene. In this study, hardwood and softwood fibers were inoculated with a white rot fungus and incubated in a climate chamber at 25 °C and 65% relative humidity for 15 and 30 days. Mycelium based medium density fiberboards were produced either without using any adhesive or with using 6% urea formaldehyde adhesive. The MOE, MOR, IB, thickness swelling and water absorption percentage of the mycelium based MDF were determined. The results showed that the MOE, MOR and IB values of the mycelium based MDF were low and did not meet the minimum required strength values given in the standards. However, these boards may still be used as insulation materials.
Keywords: Mycelium composites, MDF, white-rot fungi, mechanical properties, physical properties.

1. INTRODUCTION

Mycelium composites have been popular recently worldwide in terms of research interest and commercialization. Mycelium composites are biodegradable, produced renewable materials, environmentally friendly and show low density, good insulation properties, both related to acoustic and thermal aspects. However, mechanical properties of mycelium composites are obviously lower than alternative materials such as expanded polystyrene. Mycelium is the vegetative part of a fungus or fungus-like bacterial colony, consisting of a mass of branching, thread-like hyphae. Mycelium binds organic matter through a network of hyphal microfilaments in a natural biological process able to be exploited to produce both low-value materials, such as packaging, and higher-value composite materials from problematic agricultural and industrial waste materials with little or no commercial value [1]. Mycelium composite materials such as foams, packaging materials, accessory materials, insulation boards etc., have been developed and some of them are available in the market in recent years. For example, Dell uses mycelium foams for packaging of business servers and IKEA has also expressed interest in adopting mycelium-

* Corresponding Author: e-mail: gezer@ktu.edu.tr, tel: (462) 377 15 32

based packaging [1]. However, there are not many studies about mycelium based medium density fiberboards (MDF) in the literature. In addition, as is known, urea formaldehyde adhesive is commonly used in MDF production. It is also known that the formaldehyde emission from MDF containing formaldehyde above the standard amounts has a negative impact on the environment and human health. Formaldehyde emission causes severe allergic reactions in the skin, eye and respiratory system, weakens the immune system, and causes cancer like health problems depending on the con centration in the environment, exposure time and shape [2]. Therefore, so many scientists are still trying to find a way to decrease/lower or eliminate the formaldehyde emissions from MDF. In order to solve this formaldehyde emission problem from MDF, mycelium based MDF production might be a very good option.

The objectives of this study were to produce mycelium based MDF either without using any adhesive or with using only 6% phenol formaldehyde adhesive and to determine some mechanical and physical properties of the mycelium based MDF.

2. MATERIAL AND METHODS

Mixture of hardwood and softwood fibers (50/50%) was obtained from Kastamonu Integrated Wood Industry Company. Commercial urea-formaldehyde (UF) resin was provided by Camsan Wood Industries and Trade. Fibers were then moisturized around 70% and pH was adjusted to around 7 before the sterilization.

White-rot fungus culture was obtained from USDA Forest Products Laboratory, Wisconsin, USA. Fibers contained around 70% moisture content were put in polyethylene bags and sterilized at 121°C for 30 mins. The bags were then placed and cooled off in the laminar flow inoculation cabinet. A white-rot fungus mycelium was inoculated and then the bags were then incubated in a climate cabinet at 25 °C and 70% relative humidity for 15 and 30 days. One group of the incubated fibers was subjected to MDF production without using any resin while other group of the incubated fibers was dried to 2% initial moisture content before resin blending. The calculated quantities of the components were mixed. A UF resin (6 % solid resin based on wood oven-dry weight and 2% catalyst was applied based on wood oven-dry weight) were applied directly to the wood fibers using an air-pressure spray nozzle. The blended fibers were formed on steel caul-plates into one-layer mats of 40 mm x 40 mm (Figure 1). The mats were manually pre-pressed. These mats were pressed at a temperature of 180 °C for 7 min in a computer-controlled press (Figure 2) and conditioned in a climate room until they reached equilibrium moisture content. After climatizing of MDF panels, the specimens were cut from these panels to determine some physical and mechanical properties.

Figure 1. Preparation of mycelium based MDF

Figure 2. Production of mycelium based MDF

Some physical and mechanical properties of mycelium based MDF panels were determined according to EN 310 (1993) [3], EN 317 (1993) [4], EN 319 (1993) [5] and EN 319 (1993) [6] standards (Figure 3).

Figure 3. Mechanical tests of mycelium based MDF

3. RESULTS AND DISCUSSION

The results section should detail the main findings and outcomes of your study. You should use tables only to improve conciseness or where the information cannot be given satisfactorily in other ways such as histograms or graphs. Tables and figures should be numbered serially and referred to in the text by number.

3.1. Physical Properties

The average values of physical properties results (water absorption (WA) and thickness swelling (TS) for 24 h) of MDF panels are represented in Table 1. Furthermore, the density values of mycelium based MDF panels ranged from 630 to 680 kg/m3.

Table 1. Water absorption of mycelium based MDF

Incubation Period	UF content %	WA %	TS %
15 days	6	112.56 (13.61)	45.70 (4.55)
30 days	6	110.39 (5.78)	39.09 (3.47)

The results showed that incubation duration did not affect the water absorption percentage; however, thickness swelling decreased with increase in the incubation duration. The reason for this could be explained that the intensity and density of the mycelium/hyphea increases with the incubation duration. Therefore, mycelium binds more organic matter through a network of hyphal microfilaments which make difficult water molecules to bind organic material, in this case fiber. Haneef et al. [7] reported that a low water uptake in mycelial mats is because of the hydrophobic nature of some fungal proteins and glycol-proteins, such as hydrophobins. Sun et al., [8] developed and investigated novel hybrid panel composites based on wood, fungal mycelium, and cellulose nanofibrils. They found that the water absorption and thickness swelling of the mycelium-based composites they produced were around 120% and 70%, respectively.

3.2. Mechanical Properties

The average values for the modulus of rupture (MOR), modulus of elasticity (MOE) and internal bond strength (IB) of MDF panels are represented in Tables 2 and 3, respectively.

Table 2. MOE and MOR values of mycelium based MDF

Incubation Period	UF content %	MOR N/mm2	MOE N/mm2
15 days	0	3.84 (1.02)	480.73 (125.69)
15 days	6	3.33 (1.04)	514.15 (125.28)
30 days	6	7.15 (1.25)	848.92 (105.20)

The results showed that the highest MOR and MOE values were found for the mycelium based MDF produced from 30 days incubated fibers with 6% UF adhesive. The MOR value for the mycelium based MDF produced from 15 days incubated fiber with 6% UF was even lower than that of produced without adhesive. However, the MOE value for the mycelium based MDF produced from 15 days incubated fiber with 6% UF was lower. All the mycelium MDF investigated in this study did not meet required minimum strength values specified in the standard. Other researchers [7, 8] also reported that mycelium composite material's strength values were lower than the composites produced from virgin fiber/chips/particles mixed with higher amount of adhesive. The reason for the lower strength values for he mycelium based MDF was that there was not sufficient adhesion among the fibers with mycelium network.

Table 3. IB values of mycelium based MDF

Incubation Period	UF content %	IB N/mm2
15 days	0	0.05 (0.01)
15 days	6	0.02 (0.01)
30 days	6	0.11 (0.03)

Table 3 shows that similar findings were found for internal bonding of the mycelium based MDF investigated in this study. The reason for the weak internal bonding strength clearly revealed that there was not sufficient adhesion among the fibers with mycelium network.

4. CONCLUSION

The results showed that the MOE, MOR and IB values of the mycelium based MDF were low and did not meet the minimum required strength values given in the standards. However, these boards may still be used as insulation materials.

Acknowledgments

This study has been funded by TUBITAK (Project no: 118O145).

REFERENCES

[1] Jones, M., Mautner, A., Luenco, S., Bismarck, A., & John, S, "Engineered mycelium composite construction materials from fungal biorefineries: A critical review", Materials and Design. 187 (2020) 108397.

[2] Istek , A., Ozlusoylu, I., Onat, S.M., "Formaldehyde Emission Problems and Solution Recommendations for Wood Composite Panels", International Conference on Engineering Technologies (ICENTE'17). December 07-09, 2017, Konya, Turkey.

[3] EN 310 (1993). "Wood-based panels. Determination of modulus of elasticity in bending and of bending strength," European Committee for Standardization, Brussels, Belgium.

[4] EN 317 (1993). "Particleboards and fiberboards. Determination of swelling in thickness after immersion in water," European Committee for Standardization, Brussels, Belgium.

[5] EN 319 (1993). "Particleboards and fiberboards. Determination of tensile strength perpendicular to the plane of the board," European Committee for Standardization, Brussels, Belgium.

[6] EN 323 (1993). "Wood-based panels – Determination of density," European Committee for Standardization, Brussels, Belgium.

[7] Haneef, M.; Ceseracciu, L.; Canale, C.; Bayer, I.S.; Heredia-Guerrero, J.A.; Athanassiou, A. "Advanced materials from fungal mycelium: Fabrication and tuning of physical properties". Sci. Rep. 2017, 7, 41292.

[8] Sun, W., Tajvidi, M., Hunt, C. G., McIntyre, G., & Gardner, D. J. 2019. Fully Bio-Based Hybrid Composites Made of Wood, Fungal Mycelium and Cellulose Nanofibrils. Scientific Reports, 9(1), 3766.