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DIFFERENT TYPES OF WASTE MELAMINE IMPREGNATED PAPER (MIP) IN PARTICLEBOARD MANUFACTURING

İbrahim Halil BAŞBOĞA *
Research Ast. - Kahramanmaras Sutcu Imam University
Faculty of Forestry, Forest Industry Engineering
Address: Kahramanmaras Sutcu Imam University 46100, Kahramanmaras, Turkey
Email: ihbasboga@gmail.com

Fatma BOZKURT
Graduate student - Kahramanmaras Sutcu Imam University
Faculty of Forestry, Forest Industry Engineering
Address: Kahramanmaras Sutcu Imam University 46100, Kahramanmaras, Turkey
Email: bozkurtfatima@gmail.com

İlkay ATAR
Research Ast. - Kahramanmaras Sutcu Imam University
Faculty of Forestry, Forest Industry Engineering
Address: Kahramanmaras Sutcu Imam University 46100, Kahramanmaras, Turkey
Email: iatar@ksu.edu.tr

Fatih MENGELOĞLU
Prof. Dr. - Kahramanmaras Sutcu Imam University
Faculty of Forestry, Forest Industry Engineering
Address: Kahramanmaras Sutcu Imam University 46100, Kahramanmaras, Turkey
Email: fmengelo@ksu.edu.tr

Abstract:
Two different types of waste melamine impregnated paper (WMIP) were generated in the manufactured coated board product plants. First one is obtained when the neat décor papers were impregnated (in the impregnation line) with melamine urea formaldehyde and other chemicals (WMIP1). The second one is generated during the coating of the melamine impregnated papers on the board surfaces (WMIP2). In this study, the utilization of both WMIPs in the production of particleboard as an adhesive-replacement was investigated. First, waste melamine impregnated papers (WMIPs) granulated into flour form using Pulverizator with cooling capabilities. Then, they were dry-mixed with surface and core layer particles at 10% or 15% loadings. Three different WMIPs (WMIP1, WMIP2 or their mixtures - 70% WMIP1+30% WMIP2) were used as adhesive-replacement. Mechanical properties including bending strength, modulus of elasticity, internal bond strength and surface stability of the samples were determined according to EN 310, EN 319 and EN 317 standards, respectively. Based on the results, the type of WMIP had significant effect on all mechanical properties investigated. Particleboards produced with both 10% and 15% of WMIP1 loading provided adequate results for the related standards. The best result was obtained when 15% of WMIP1 was used. It is concluded that WMIP1 might be used as an adhesive-replacement in particleboard manufacturing and may provide economic and environmental benefits.

Key words: *mechanical properties of particleboard; melamine impregnated paper waste; melamine urea formaldehyde resin.*

INTRODUCTION

Wood Based Panel sector in Turkey is a fast developing sector and has important place in Europe and World. The increase in furniture manufacturing and their acceptance in markets have triggered the raw material import for wood panel manufacturing and the use of coated panel products for these applications. Coated material are preferred in furniture applications due to their improved aesthetical appearances and mechanical properties, reduced moisture sorption, and minimized formaldehyde emissions (Nemli ve ark 2005). Melamine impregnated paper (MIP) is one of the most preferred coated material in particleboard sector. Over the years, several successful studies were done on MIP coating of wood based panels.

Melamine impregnated paper (MIP) consists of decor paper (40%) and adhesives (melamine, urea, formaldehyde, crosslinker and hardener). MIP manufacturing was done by impregnating decor paper (alfa celluloses) with melamine formaldehyde (MF) or combination of MF and urea formaldehyde (UF). During this

* Corresponding author

process, two different types of waste-MIP (WMIP) occur. First one is generated in the impregnation line and obtained from (WMIP1). During this process, WMIPs were dried about 70 seconds in drying oven under 140-170°C temperature. Second one is obtained from melamine press during coating with the melamine impregnated papers on the boards (WMIP2). In the melamine press line, MIP was exposed the heat (170°C) second time for 15 seconds.

During MIP preparation, almost 0.6% waste was generated (WMIP1). Additional waste was generated during the MIP coating on panel surfaces (WMIP2). MIP contains chemicals (adhesives, curing agents, crosslinking agents etc.) and it is not suitable for generating energy through burning them. It is required special running boilers at higher temperatures (Barbu and Steinwender 2009). WMIPs still have some reactive adhesive, since they are not fully cured during manufacturing process. There is still a need finding ways to reuse them. Researches have looked for alternative ways to utilize these wastes. Ayrılmış (2012) grinded WMIP with hammer-mill in the size of 2-3mm and mixed them with glued fibers in fiberboard manufacturing. It was reported that mechanical properties were improved with the addition of MIP amount. In another study, Alpar and Winkler (2006) manufactured single layer particleboard using WMIP powder as filler and adhesives. There was no significant differences on the properties of urea formaldehyde (UF) bonded boards and MIP powder bonded ones. In another study, Silva *et al*. (2012) used 6mm long MIP wastes at 4%, 8% and 12% loading in the core section of medium density particleboard. During this study, adhesive amount was kept same. Particleboard having 4% and 8% MIP waste satisfied the standards but 12% ones did not. The utilization of MIP waste in the oriented strand board (OSB) was also studied by Cavdar *et al*. (2013). They used MIP waste at 10% increments up to 50% as filler in OSB core section. Results showed some improvements on mechanical and physical properties.

Previous studies showed that there is a potential for WMIPs to be utilized in wood panel manufacturing as an adhesive. However, there is still a need to understand the role of where the waste is generated. Main goal of this study was to evaluate the adhesive-replacement potential of waste melamine impregnated paper 1 (WMIP1) and waste melamine impregnated paper 2 (WMIP2). For this purpose, three-layer particleboards were manufactured with two different rates of WMIP1, WMIP2 and mixture of WMIP1 and WMIP2 for this study. Mechanical properties of the samples were determined according to TS EN 310, TS EN 311 and TS EN 319 standards.

MATERIAL AND METHODS

Materials

Particleboards were produced utilizing two different types of waste melamine impregnated paper (WMIP), which are obtained from the impregnation line (WMIP1) and melamine press (WMIP2). No additional adhesive was used. Two different types of mixture of Turkish red pine and poplar wood particles (fine and coarse) were used. WMIPs were received from Kastamonu Integrated Adana MDF Facility. Particles were obtained from Kastamonu Integrated Tarsus Particleboards Facility.

Particleboard Manufacturing

Waste melamine impregnated papers (WMIP) granulated into flour form using Pulverizator with cooling capabilities and used without further classification. The experimental design of the study was presented in Table 1.

Table 1

Manufacturing schedule of Particleboards

ID	WMIP1(%)	WMIP2(%)	WMIP1+WMIP2 (%)
WMIP1+10	10*	-	-
WMIP1+15	15	-	-
WMIP2+10	-	10	-
WMIP2+15	-	15	-
Mix+10	-	-	10
Mix+15	-	-	15

***** Based on the dry weight of particles

During board manufacturing, WMIP1, WMIP2 and their mixture (Mix) were used as adhesive replacements. Mix group had mixture of 70% WMIP1 and 30% WMIP2. They mixed in high-intensity mixer and used in board-type Mix+10 and Mix+15. Fine and coarse particles were utilized in surface layers (SL) and in core layer (CL), respectively. Six different particleboards with three layers were manufactured. The core layer was accounted for 67% of the total board weight. Surface layers were contained 33% of the total board weight.

Depending on the formulation, particles and MIP were dry-mixed in a high-intensity mixer to produce a homogeneous blend. Same adhesive rates were used for core and surface layers. The blends were laid into frame of 500mmx500mm. A hot press was used for forming of particleboards (90-120 Bar). 19mm security bars were used for two sides of mat. Pressing time and temperature were 240s and 195°C, respectively. After pressing, particleboards were conditioned at a temperature of 20°C and 65% relative humidity. The conditioned boards were cut from four edges and sanded to 18mm thickness. Finally, test samples were cut according to TS EN standards.

Particleboard testing

Boards were manufactured and test samples were cut. Boards manufactured using only WMIP2 as an adhesive-replacement did not have enough strength for trimming, sample cutting and testing. Testing of the successfully produced sample groups was conducted in a climate-controlled testing laboratory. Densities were measured by air-dried density method according to the TS EN 323 standard. Bending strength, modulus of elasticity, internal bond strength and surface soundness of the samples were determined according to TS EN 310, TS EN 319 and TS EN 311 standards, respectively. Five samples for each group were tested. Mechanical property tests were performed on Zwick Z010 (10KN).

RESULTS AND DISCUSSION

Particleboards were produced in the density range of 521-643 kg/m^3. In this study, bending strength, modulus of elasticity, internal bond strength and surface soundness of all samples were determined. (Except for WMIP2+10 and WMIP2+15). The arithmetic mean and standard deviation of tested groups were given in Table 2.

Table 2

Summarize of the mechanical properties values

ID	Internal bond strength (MPa)	Bending strength (MPa)	Modulus of elasticity (MPa)	Surface soundness (MPa)
WMIP1+10	0.42 (0.06)	13.7 (1.51)*	2312.2 (140.0)	1.02 (0.04)
WMIP1+15	0.48 (0.09)	15.7 (2.47)	2646.8 (359.1)	1.31 (0.14)
Mix+10	0.10 (0.01)	3.74 (0.61)	938.21 (157.9)	0.21 (0.01)
Mix+15	0.18 (0.02)	3.87 (1.51)	1265.29 (46.7)	0.45 (0.13)
Std	≥ 0.35	≥ 13	Min. 1600	≥ 0.8

* Values in parenthesis are standard deviations.
Std: Standard values

The graph of internal bond strength (IB) was presented in Fig. 1. In this study, mean IB values of the samples were between 0.10 and 0.48MPa. Since required IB values should be over 0.35MPa, only board-type WMIP1+10 and WMIP1+15 passed this requirement. Results also showed that IB was increased with rising percentage of WMIP1. Board-types Mix+10 and Mix+15 were not satisfied the standard requirements for IB. WMIP type had significant effect on the internal bond strength. WMIP1 was more effective than WMIP2. It is believed that WMIP2's second exposure to heat at melamine press (170°C for 15 seconds) reduced their reactivity. This resulted in a reduced IB strength for boards produced with WMIP2.

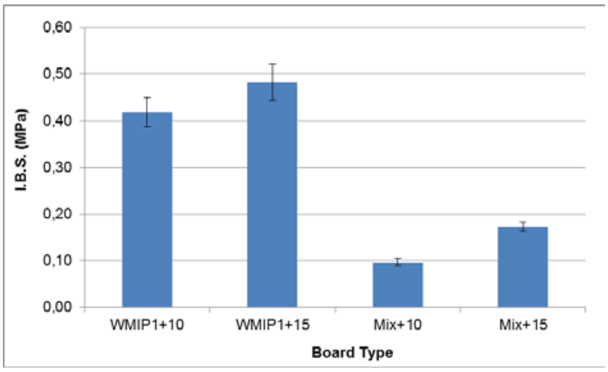

Fig. 1.
Bar graphs of internal bond strength.

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The graph of bending strength was provided in Fig. 2. Once again, all particleboards manufactured with WMIP1 satisfied the standard requirements of 13MPa for bending strength. Similar to the IB strength result, board-types Mix+10 and Mix+15 boards did not satisfy the standard requirements.

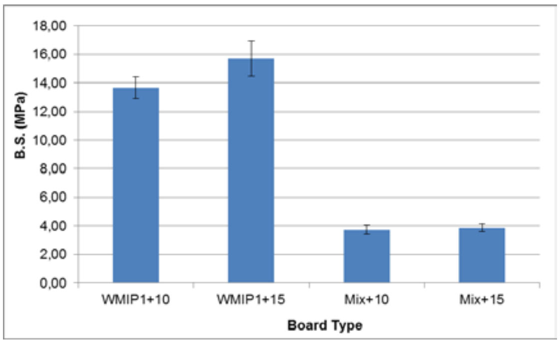

Fig. 2.
Bar graphs of bending strength.

Modulus of elasticity values were presented in Fig. 3. Similar to the bending strength, board-types WMIP1+10 and WMIP1+15 satisfied the required standard values of 1600MPa. Once again board-types Mix+10 and Mix+15 were failed to meet this standard. There was a slight increase on modulus properties with increase of WMIP amount but it was not statistically significant.

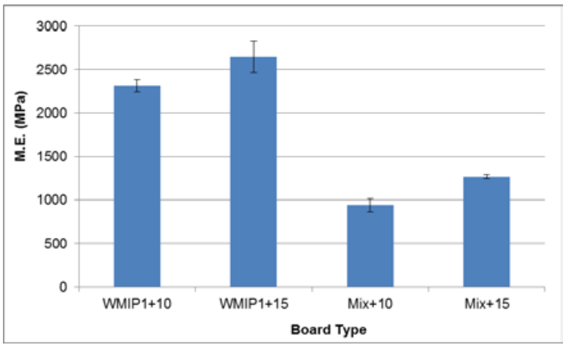

Fig. 3.
Bar graphs of modulus of elasticity.

Surface soundness properties were shown in Fig. 4. Based on the results, both board types of WMIP1+10 and WMIP1+15 provided surface soundness values over the standard requirement of 0.8MPa. Increase of the WMIP1 concentration in the particleboard, improved the soundness properties. In the case of Mix+10 and Mix+15, they did not meet the standard requirements. It should be noted that compared the Mix+10), Mix+15 provided surface soundness properties twice as much (0.20MPa vs 0.42MPa).

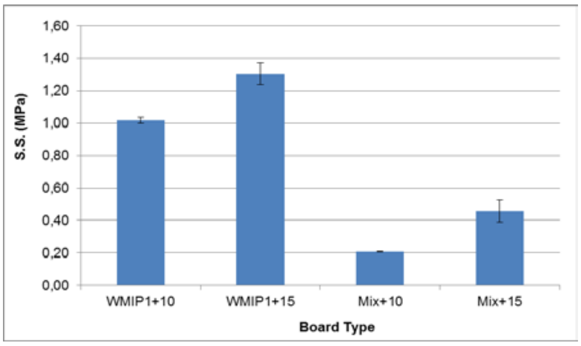

Fig. 4.
Bar graphs of surface soundness.

Moreover, all the data and standard requirement were summarized in Table 3. Values matching standards was painted in green and if not, it was painted in red.

Table 3

Summary of Mechanical and Physical properties of Particleboards

Board ID	Internal bond strength	Bending strength	Modulus of elasticity	Surface soundness
WMIP1+10				
WMIP1+15				
Mix+10				
Mix+15				
Standard Values	≥ 0.35	≥ 13	Min. 1600	≥ 0.8

Conclusion

Waste Melamine Impregnated Papers (WMIPs) was utilized as an adhesive-replacement in particleboard manufacturing and the following conclusions were reached:

1. Waste generated during melamine impregnated paper (MIP) manufacturing (WMIP1) provided better internal bond strength (IB), bending strength (BS), modulus of elasticity (MOE) and surface soundness (SS) values compared to waste generated MIP coating (WMIP2) and mixture of WMIP1 and WMIP2.
2. Particleboards meeting required standards were manufactured using only 10% WMIP1 without any additional adhesive.
3. With increasing concentration of WMIP1, higher IB, BS, MOE and SS values were achieved,
4. In the study range of 10% and 15%, boards produced with mixture of WMIP1 and WMIP2 did not meet the standards requirements. There were some increase in IB, BS, MOE and SS values when mixture concentration was increased from 10% to 15%.
5. Particleboards were not able to be produced using WMIP2 as an adhesive-replacement alone due to the their possible reduced reactivity.

As a result, WMIP waste might be utilized in particleboards industry. This could provide benefit to the company and the environment by providing extra income and reducing waste, respectively. In future studies, higher mixture (WMIP1+WMIP2) loading and different mat moisture contents should be investigated.

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