ONLINE ISSN 2069-7430
ISSN-L 1841-4737

PRO LIGNO
www.proligno.ro

Vol. 13 N° 4 2017
pp. 236-241

SOME PROPERTIES OF DECORATIVE MDF PANELS MANUFACTURED FROM COLOURED WOOD FIBERS

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Abstract:
In this study, some properties of Medium Density Fiberboard (MDF) panels manufactured from the coloured fibers with various dyes were investigated. The effects of these dyes on the colour change, surface roughness parameters, water absorption and thickness swelling of the MDF panels were evaluated. The results showed that while the highest total colour change value was obtained with the MDF samples manufactured from the coloured fibers using methylene blue, the lowest total colour change value was recorded with the MDF samples manufactured from the coloured fibers using indigo carmine. The surface roughness values of the coloured MDF samples were found lower than that of the control MDF sample. The water absortion (WA) and thickness swelling (TS) increased in the coloured MDF samples. It was found that, all values changed depending on the type of dyes.

***Key words**: MDF; Coloured MDF; fiber; dye; colour change; surface properties; physical properties.*

INTRODUCTION

Nowadays, architects, interior designers and furniture manufacturers have been in search of high-quality wood based panels which are creative solutions for furniture and room design to allow for the highest level of customer expectation and satisfaction (URL 1). The panel producers have developed new technologies and products to satisfy the customer needs.

Wood based panels are widely used in furniture manufacturing, strengthened floor, wall panels for interior decoration and many other applications. Medium Density Fiberboard (MDF) has smoother surface and more homogenous density than other wood based panels. Therefore, it is used as a core material for furniture field. MDF provides a good substrate for wood veneers, laminates and paint (Maloney 1993).

Coloured MDF provides many facilities to designers inspiring their designs. It is versatile and suitable material for an extensive variety of applications (URL 2).

Dyes and pigments are most important colouring agents. They are extensively used for many areas such as textile, food, cosmetics, plastics, pharmaceutical, ink, paint and paper industries (Gürses et al. 2016). Dyes may be classified according to several ways such as appplication class, chemical structure, and end use (Adegoke and Bello 2015). Safranin is among the oldest known synthetic dyes. It is primarily used as food dye. Safranin is also used as dye for cotton, wool, bast fibers, silk, leather, tannin, paper (Guler et al. 2016) and plant microscopy (Bond et al. 2008). Methylene blue is widely used for dyeing silk, cotton and wood. It is known that it has strong adsorption onto solids (Shahryari et al. 2010). Indigo carmine is one of the most useful dyes that is used as colourant in the textile industry, and additive in pharmaceutical tablets and capsules (de Carvalho et al. 2011). It is also used as colourants for food (Fleischmann et al. 2015).

Many studies have been conducted to investigate the effect of various dyes for wood and wood materials (Hu et al. 2016; Özen et al. 2014; Yeniocak et al. 2015; Göktas and Yeniocak 2016).

OBJECTIVE

The objective of this study was to evaluate the colour change, surface roughness parameters, water absorption and thickness swelling of the MDF panels manufactured from the coloured fibers with various dyes (indigo carmine, methylene blue and safranin) which they are commonly used in different areas.

MATERIALS AND METHODS

In this study, commercial softwood fibers were used as raw material. As dyes for colouration of fibers, indigo carmine, methylene blue and safranin powders were used. The dyes were supplied by Merck Co., Germany.

ONLINE ISSN 2069-7430
ISSN-L 1841-4737
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Vol. 13 N° 4 2017
pp. 236-241

Colouration of Fibers

Aqueous solutions were prepared at 0.1 % concentration of each dye for 2L water. Wood fibers were treated with the solutions of indigo carmine, methylene blue, and safranin by soaking in a tank for 24 hours. Later fully saturated coloured fibers were dried in a laboratory oven until they reach 2–3% moisture contents. Dried fibers were also screened to separate fiber bundles. The coloured fiber samples were represented in Fig.1.

(a) (b) (c) (d)

Fig. 1.
a - fibers without dye(uncoloured); b - coloured fibers with safranin; c - coloured fibers with methylene blue; d - coloured fibers with indigo carmine.

Manufacture of MDF Panels

The fibers were mixed in a rotary drum equipped with resin spraying unit. Urea formaldehyde (UF) was used as adhesive. The mats manually were formed and pressed in a press for 170˚C, 7min. After manufacturing, the MDF samples were conditioned in a climate room with a temperature of 20˚C and a relative humidity of 65˚C until they reach to equilibrium moisture content before tests. Fig. 2 shows the coloured panel mats.

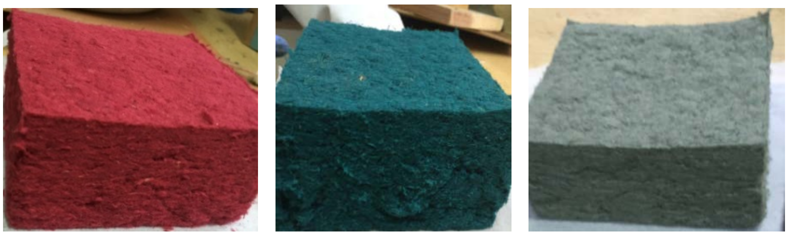

Fig. 2.
Coloured panel mats.

Colour Measurements

The colour measurements of the coloured samples were carried out using by Mitech Technology MCD-100 spectrophotometer according to the CIE $L^*a^*b^*$ system (HunterLab 2008). The ΔL^*, Δa^*, Δb^* colour coordinates, and total colour change (ΔE^*) occurring in the samples were calculated.

Surface Roughness

The surface roughness parameters such as *R*a, *Rq* and *R*z of the MDF samples were measured using Mitutoya Surftest SJ-210 instrument according to DIN 4768 standard.

Water Absorption and Thickness Swelling

The water absorption and thickness swelling values of the MDF samples for 24h were determined according to EN 317 standard.

RESULTS AND DISCUSSION

Colour measurements

Some images of the uncoloured/coloured samples were given in Fig. 3. As can be seen in Fig. 3, the dyes gave different colours to fibers. The colour of fibers turned into red with safranin dye, to blue with methylene blue, and to green colour with indigo carmine.

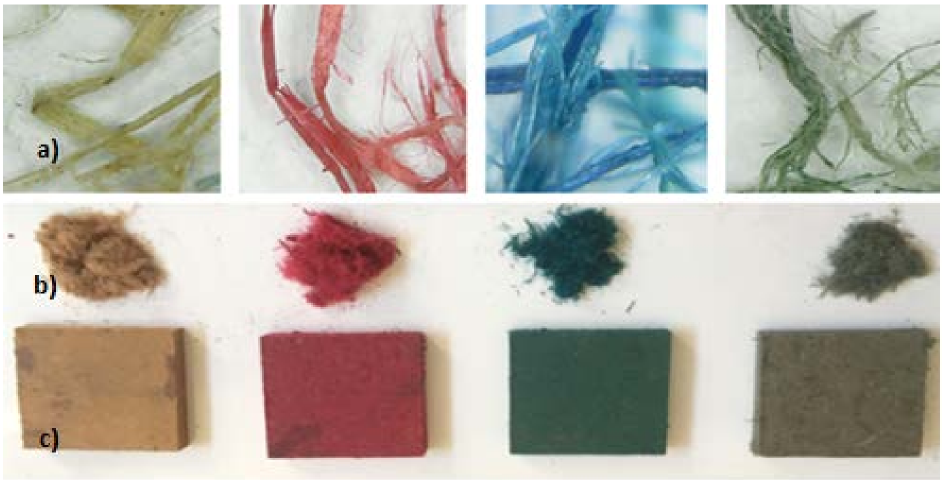

Fig. 3.
a - Microscopic images of the fibers; b - uncoloured/coloured fibers; c - uncoloured/coloured MDF samples.

The colour measurement results of the coloured fibers and coloured MDF panels were represented in Table 1.

Table 1

Colour changes of fibers and MDF samples

	Groups	Δ*E**	Δ*L**	Δ*a**	Δ*b**
MDF	Red MDF	27.8	-14.8	18.2	-149
	Blue MDF	34.4	-14.4	-22.1	-221
	Green MDF	17.4	-5.1	-10.7	-127
Fibers	Red fiber	8.3	-4.4	7.0	2
	Blue fiber	12.4	-7.5	-5.3	-83
	Green fiber	5.7	-1.8	-3.9	-37

*The MDF panels with safranin labeled as red MDF; the MDF panels with indigo carmine labeled as green MDF; the MDF panels with methylene blue labeled as blue MDF.
** Control groups were taken as reference for color measurements.

Table 1 displays the colour change values of the coloured MDF panels. Each groups showed different color change depending on the type of dye. The Δ*E** value was highest for blue MDF samples manufactured from the coloured fibers with methylene blue. This value was found to be 34.4. The lowest Δ*E** value was found to be 17.4 for green MDF samples manufactured from the coloured fibers with indigo carmine. The Δ*L** was determined to be the lowest value (-5.1) for green MDF samples. The negative Δ*L** values were found similar for red MDF and blue MDF samples.

The results also show that the chromaticity coordinates, the Δ*a** and Δ*b** for the MDF samples were found as positive and negative values. Positive and negative values of Δ*a** indicate a tendency of sample surface to become reddish and greenish. Positive and negative values of Δ*b** indicate a tendency of sample surface to become yellowish and bluish, respectively (HunterLab 2008). As can be seen from Table 1, the highest Δ*a** value was 18.2 for red MDF samples. This positive value represents a tendency to red colour. The negative Δ*a** values of green MDF and blue MDF indicate that they have tendency to green colour. All Δ*b** values of the MDF samples were found as negative. The highest negative Δ*b** value was obtained from blue MDF samples.

Table 1 also displays that the same trend was observed for colour change values of the coloured fiber samples. The highest Δ*E** value was found to be 12.4% for blue fibers, the lowest Δ*E** value was found to be 5.7% for green fibers. The lowest Δ*L** value was recorded from green fibers. The highest Δ*L** value was found for blue fibers. Additionally, it is seen that all colour change values of the MDF panels were found higher than those of the fibers. Probably, these differences can be ascribed to panel manufacturing parameters, additives, and etc.

Surface properties

The surface parameters values of the control MDF and coloured MDF panels manufactured with different dyes were represented in Table 2. The evaluation profiles of the MDF samples also were given in Fig.4-7.

ONLINE ISSN 2069-7430
ISSN-L 1841-4737
PRO LIGNO
www.proligno.ro
Vol. 13 N° 4 2017
pp. 236-241

Table 2

Surface roughness values of MDF samples

Groups	Ra(µm)	Rq(µm)	Rz(µm)
Red MDF	4.85	6.27	31.96
Blue MDF	5.02	6.26	29.75
Green MDF	5.35	6.64	31.04
Control	5.68	7.11	32.59

As can be seen from Table 2, the surface roughness of all coloured MDF samples decreased in comparison with the control MDF sample.The highest surface parameters (Ra, Rq, Rz) were obtained from the control MDF samples. The red MDF samples resulted in the smoothest surface with the Ra value of 4.85µm, while corresponding value for the control sample was 5.68µm. The lowest value of Rq was found to be 6.26µm for blue MDF samples; the highest value of Rq was 7.11µm for control MDF samples. While the highest value of Rz was recorded from the control MDF samples, the lowest value of Rz was found for blue MDF samples. The values changed depending on the type of dyes. It is known that the degree of surface roughness is a function of manufacturing parameters and raw material properties (Hiziroglu and Kosonkorn 2006).

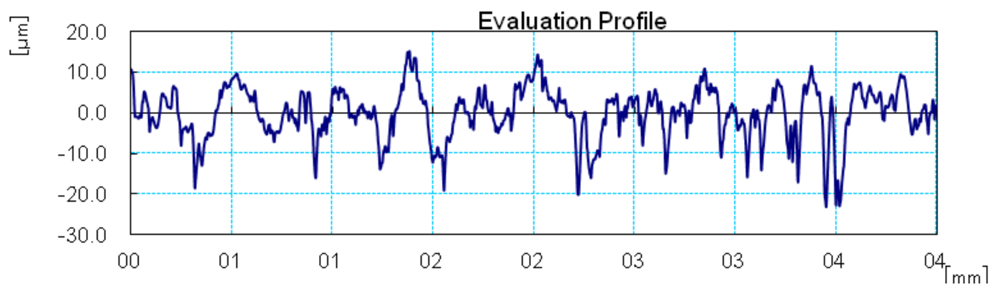

Fig. 4.
Evaluation profile of red MDF.

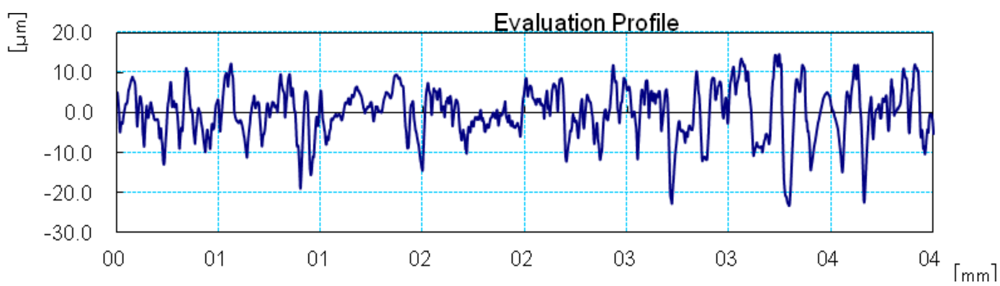

Fig. 5.
Evaluation profile of blue MDF.

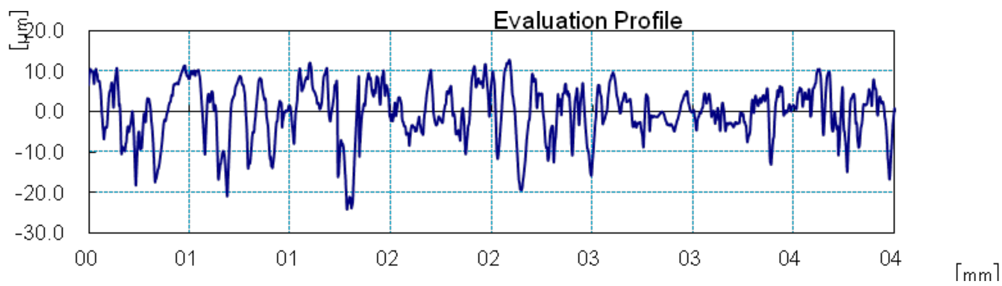

Fig. 6.
Evaluation profile of green MDF.

ONLINE ISSN 2069-7430
ISSN-L 1841-4737
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www.proligno.ro
Vol. 13 N° 4 2017
pp. 236-241

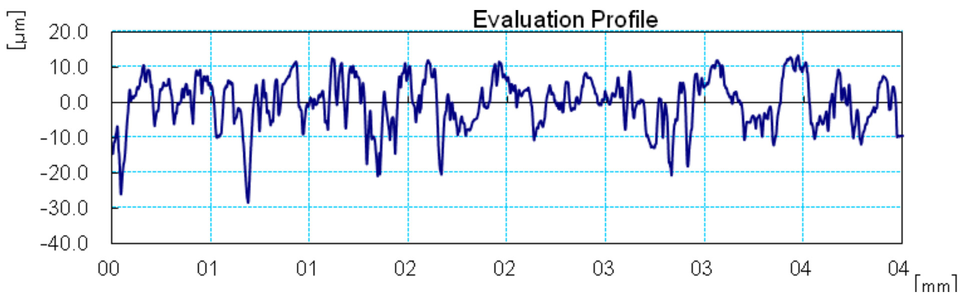

Fig. 7.
Evaluation profile of control MDF.

Water Absorption and Thickness Swelling

The results of the water absorption and thickness swelling of the MDF panels were given in Table 3.

Table 3

Water absorption and thickness swelling of MDF samples

Groups	WA(%)	TS(%)
Red MDF	52.48	20.60
Blue MDF	54.87	21.82
Green MDF	60.66	23.12
Control	32.03	14.80

As can be seen in Table 3, the water absorption values of the coloured MDF samples for 24h were found higher than the value of control MDF sample. The WA value was found to be 32.03% for the control MDF panels; the highest value was obtained to be 60.66% for green MDF panels. The lower value was found for red MDF panels among the all coloured MDF samples. Similarly, same trend was obtained for TS values. The lowest TS value was found to be 14.80% for the control MDF panels. The highest TS value was determined to be 23.12% for green MDF panels, respectively. The results demonstrated that the type of dye in the MDF panels caused an increase on the water absorption and thickness swelling values. This increase can be attributed to chemical structure of these dyes.

CONCLUSIONS

The findings of this study showed that the dyes have effect on the some properties of the MDF panels such as surface roughness, colour change, water absorption and thickness swelling. All values showed different trend depending on the type of dye. The highest color change values were obtained from blue MDF panels. The highest surface roughness parameters were recorded from the control MDF samples. The water absorption and thickness swelling values of the coloured MDF panel samples increased depending on the type of dye. It appears that the alternative dyes, pigments and additivities can be used to improve the some properties of panels.

As a conclusion, coloured MDF panels can be used effectively without laminating or edge banding in many areas where they have potential usage.

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