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Physical and Mechanical Properties of UF Bonded and Without Binding Agent Bagasse MDF

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ABSTRACT

This study summarizes the results of Medium Density Fiberboard (MDF) made from bagasse using urea formaldehyde as a binder agent and without binding agent. Important physical and mechanical properties were examined. The density of MDF bagasse with binding agent and without binding agent was respectively 0.90 and 0.87 g cm^{-3}. The Modulus of Rupture (MOR) of MDF bagasse with binding agent and without binding agent was 44.98 and 34.94 N mm^{-2} respectively. The Modulus of Elasticity (MOE) was 3532.34 and 3454.28 N mm^{-2} respectively for UF bonded bagasse MDF and without binding agent bagasse MDF. Board with addition of binding agent showed higher performance than that of without binding agent board for both physical and mechanical properties. But both kind of board followed the standard and also showed better quality than that of the previous studies. There is a possibility of using MDF of bagasse for both types as a substitute of MDF made from other agricultural residues.

Key words: Medium density fiberboard, modulus of rupture, modulus of elasticity, bagasse, physical properties, mechanical properties

INTRODUCTION

Medium-Density Fiberboard (MDF) is a fibrous felted and homogeneous panel produced using wood or other lignocellulosic fibers combined with synthetic or other suitable adhesives under heat and pressure (NPA, 1994). Due to its numerous advantages over solid wood and other composite materials, the production of fiberboard has been increasing consistently. Uniform fiber distribution of fiberboards in their structure meets most end-use requirements. Smooth and solid edges of fiberboards can easily be machined and finished for various purposes, especially furniture production. Smooth and uniform surfaces also provide an excellent substrate for paint and decorative overlays. The surface smoothness of MDF makes it the best material for cabinet manufacturing (Copur *et al.*, 2008).

Various advantages of MDF, worldwide economic growth and development have generated unprecedented needs for converted forest product of MDF. The other forest products such as pulp and study, plywood and lumber are also demandable and this global demand started with the advent of the industrial revolution resulting in aggressive deforestation (Youngquist *et al.*, 1993; Adger and Brown, 1994). Agricultural residues can resolve this type of problem and utilization of them in wood industry offers numerous economic, environmental and technological advantages. These are renewable, widespread, plentiful and use them in the industry is environment friendly practice (Akgul *et al.*, 2010).

Several studies have been conducted to examine the suitability of agricultural residues in wood industry to overcome the shortage of wood. Some researchers provide accounts of world-wide research considering the utilization of non-wood plants in the forest based industry (Chow, 1974; Youngquist *et al.*, 1993, 1994). Several researchers also examined the using of wheat straw, cotton stalk, sun flower stalk and husk for the production of composites (Eroglu and Istek, 2000; Gencer *et al.*, 2001: Guler and Ozen, 2004; Bektas *et al.*, 2005; Copur *et al.*, 2008). Zare-Hosseinabadi *et al.* (2008) studied on the dry and wet stored bagasse for MDF.

In this study, it was tried to investigate the potential use of fresh bagasse for manufacturing MDF using Urea-Formaldehyde (UF) as an adhesive and without using adhesive.

MATERIALS AND METHODS

Bagasse was collected from the Sugar juice selling stores situated at Mohammadnagar, Gollamari, Khulna, Bangladesh. It was cut into small pieces that were approximately 1 inch in length manually then chips were boiled for 6 h to reduce sugar content. Next, the bagasse chips were submerged into the 20% sodium hydroxide (NaOH) solution for 24 h and washed properly to remove the chemical properly.

Washed chips were defibered using one 25 cm single disc laboratory atmospheric refiner. The refined fibers were air dried and then these were dried in an oven at 103°C to reduce moisture content at 4% for UF bonded bagasse MDF. Dried fibers were kept in sealed plastic bags until used. The refined fibers were used for making mat before drying for without binding agent bagasse MDF.

Urea formaldehyde was used 20% on the dry weight basis. Adhesive was mixed uniformly with fiber using a blender. Then mat of both types was formed on a steel sheet using an iron frame. The mats were pressed in a hot press for 60 min at 0.8 N mm^{-2} pressure but the coil of hot press was switched on for the first 30 min. The temperature was 125°C for UF bonded bagasse MDF and it was 160°C for without binding agent bagasse MDF. In case of without binding agent bagasse MDF, the board was pre pressed in a cold press before inserting into hot press because of forming mats in wet condition after just refining fiber. All boards were cooled and stored at room temperature until trimmed to their final dimensions of 30×30 cm.

The laboratory tests mainly the test of physical properties and mechanical properties for each type of MDF was carried out respectively in the Wood Technology Laboratory of Forestry and Wood Technology Discipline of Khulna University, Bangladesh and in the Laboratory of Mechanical Engineering Department of Khulna University of Engineering and Technology, Khulna, Bangladesh. Physical properties were carried out according to ASTM D 1037-100 (ASTM D 1037, 2006) standard procedures and mechanical properties were performed according to DIN 52362 (1984).

All the data, produced during the laboratory tests for characterization of physical and mechanical properties of each type of fiberboards, were analyzed by using Microsoft Office Excel 2007 and SPSS (Statistical Package of Social Survey) 11.5 software.

RESULTS AND DISCUSSION

Physical properties: The density of UF bonded bagasse MDF and without binding agent bagasse MDF was 0.90 and 0.87 g cm^{-3}, respectively (Fig. 1). The density of UF bonded bagasse MDF was

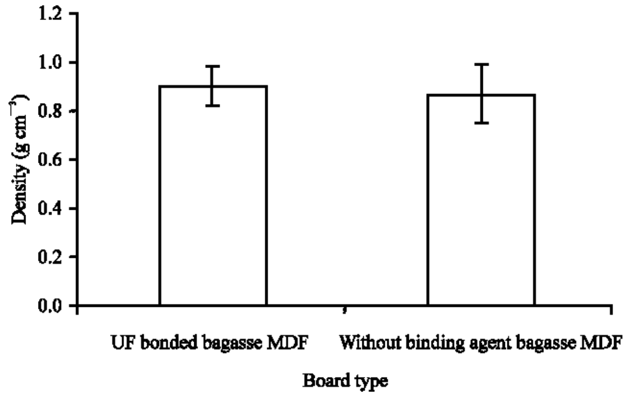

Fig. 1: Density of UF bonded bagasse MDF and without binding agent bagasse MDF

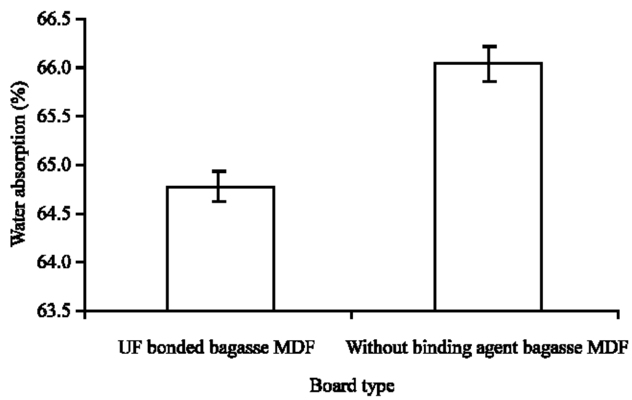

Fig. 2: Water absorption of UF bonded bagasse MDF and without binding agent bagasse MDF

higher than that of binding agent bagasse MDF. From un-paired T-test, it was found that there was significant difference (95% level of significance) between the densities of two types MDF. Binding agent helps to achieve strong bonds and compactness with particles causes increasing of density of a board (Ajayi *et al.*, 2008).

The water absorption of UF bonded bagasse MDF and without binding agent bagasse MDF was 64.79 and 66.05%, respectively after 24 h immersion in water (Fig. 2). Water absorption of UF bonded MDF bagasse was lower. Increasing compactness and strong bonds due to using binding agent inhibit the absorption of water (Ajayi *et al.*, 2008). High temperature is liable to reduce he degree of polymerization of cellulose and hemicelluloses and causes affinity to water (Habibi *et al.*, 2002; Widsten *et al.*, 2001). There was a significant difference (95% level of significance) of this property between the two types of board. The water absorption of the two types of board follows previous study (Zare-Hosseinabadi *et al.*, 2008; Habibi *et al.*, 2002; Lee *et al.*, 2004).

After 24 h immersion in water, it was found that the thickness swelling of UF bonded bagasse MDF was 16.95% but without binding agent bagasse MDF was 18.22% (Fig. 3). Statistically, it was found that there was a significant difference (95% level of significance) between the thickness swellings of the two types of board. Using of adhesive for UF bonded bagasse MDF causes compactness and strong bonds with fibers and low affinity to water. Degree of polymerization of

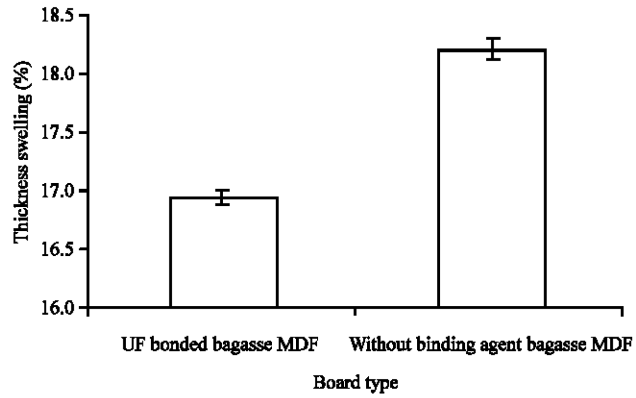

Fig. 3: Thickness swelling of UF bonded bagasse MDF and without binding agent bagasse MDF

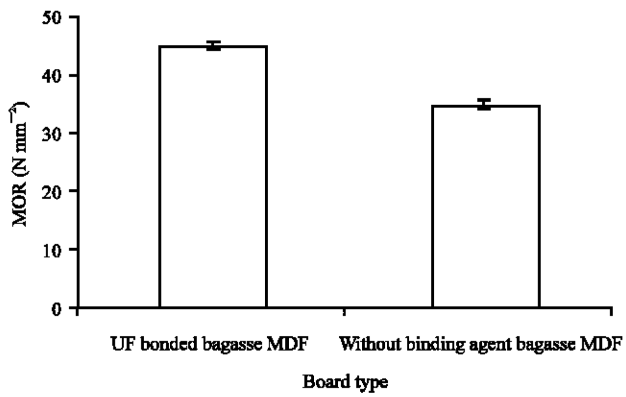

Fig. 4: MOR of UF bonded bagasse MDF and without binding agent bagasse MDF

cellulose and hemicelluloses is reduced due to increasing of temperature for without binding agent bagasse MDF (Ajayi *et al.*, 2008; Habibi *et al.*, 2002; Widsten *et al.*, 2001). This result follows previous investigation (Zare-Hosseinabadi *et al.*, 2008; Habibi *et al.*, 2002; Lee *et al.*, 2004).

Mechanical properties: The MOR of UF bonded bagasse MDF and without binding agent bagasse MDF was 44.98 and 34.94 N mm^{-2}, respectively (Fig. 4). UF bonded bagasse MDF showed higher MOR value than that of without binding agent bagasse MDF. Statistical analysis agreed that there was significant difference (95% level of significance) between the two types of board. Binding agent increases strong bond with fiber and it causes higher value of MOR. On the other hand, higher temperature causes reducing of degree of polymerization of cellulose and hemicelluloses and it is liable to achieve lower value of MOR (Ajayi *et al.*, 2008; Habibi *et al.*, 2002; Widsten *et al.*, 2001). According to ANSI (NPA, 1994), the MOR is 34.5 N mm^{-2} as well as according to Desch and Dinwoodie (1996), the standard MOR is 30 N mm^{-2}. The both type of fiberboard show the higher quality than that of the standard. This result is also higher than the values of 29.7, 12.2 and 13.0 N mm^{-2} obtained by Zare-Hosseinabadi *et al.* (2008), Habibi *et al.* (2002) and Lee *et al.* (2004), respectively.

The MOE of UF bonded bagasse MDF was 3532.34 N mm^{-2} whether it was 3454.28 N mm^{-2} for without binding agent bagasse MDF (Fig. 5). The MOE of UF bonded bagasse MDF was higher.

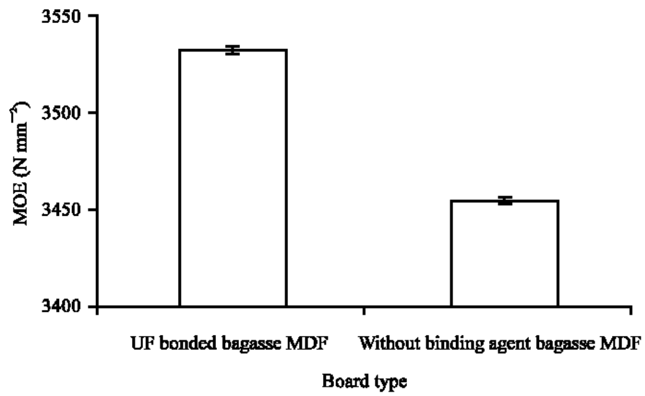

Fig. 5: MOE of UF bonded bagasse MDF and without binding agent bagasse MDF

From the statistical analysis it was found that there was significant the two types of board. Strong bond occurs due to the presence of binding agent and it increases higher value of MOE. But higher temperature causes reducing of degree of polymerization of cellulose and hemicelluloses and this leads to show lower value of MOE (Ajayi *et al.*, 2008; Habibi *et al.*, 2002; Widsten *et al.*, 2001). According to ANSI (NPA, 1994) and Desch and Dinwoodie (1996), the standard MOE is 3450 and 2500 N mm^{-2}. This study shows higher value of MOE than that of the standard value and it is also higher than 3127, 1370 and 1578 N mm^{-2} measured by Zare-Hosseinabadi *et al.* (2008), Habibi *et al.* (2002) and Lee *et al.* (2004), respectively.

CONCLUSION

The physical and mechanical properties of UF bonded bagasse MDF are higher than without binding agent bagasse. But both type of board satisfy the standard ANSI (NPA, 1994). Even their properties are higher than the standard and previous findings. This finding indicates that there is a possibility of using bagasse in the MDF industry as a raw material. This will help to solve the problem of raw material and proper utilization of bagasse. Using of bagasse in MDF industry will bring economical benefit for the country. Further study is necessary to reduce the pressing time by increasing the pressure during hot press.

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