ONLINE ISSN 2069-7430
ISSN-L 1841-4737
PRO LIGNO
www.proligno.ro
Vol. 10 N° 4 2014
pp. 35-39

WATER RESISTANCE OF WOOD - PLASTIC COMPOSITES MADE FROM WASTE MATERIALS RESULTED IN THE FURNITURE MANUFACTURING PROCESS

Camelia COŞEREANU
Ass.prof.dr.eng. - TRANSILVANIA University of Brasov – Faculty of Wood Engineering
Address: B-dul Eroilor, nr. 29, 500036, Brasov, Romania
E-mail: cboieriu@unitbv.ro

Dumitru LICA
Prof.dr.eng. – TRANSILVANIA University in Brasov – Faculty of Wood Engineering
Address: B-dul Eroilor nr. 29, 50036 Brasov, Romania
E-mail: dumitru.lica@unitbv.ro

Ioan CURTU
Prof.dr.eng. - TRANSILVANIA University of Brasov – Faculty of Mechanical Engineering
Address: B-dul Eroilor, nr. 29, 500036, Brasov, Romania
E-mail: curtui@unitbv.ro

Mariana-Domnica STANCIU
Lecturer.dr.eng. – TRANSILVANIA University in Brasov – Faculty of Mechanical Engineering
Address: B-dul Eroilor nr. 29, 50036 Brasov, Romania
E-mail: mariana.stanciu@unitbv.ro

Abstract:
The purpose of this paper is to present innovative wood-plastic composites made from waste materials such as ABS (acrylonitrile butadiene styrene) and wood shavings resulted in the furniture manufacturing process. From previous investigations (with regard to physical integrity and compactness of the panels), only mixtures ranging from a ratio of 100% ABS: 0% shavings to 80% ABS: 20% shavings were selected for water resistance testing. Swelling in thickness and water absorption for 2h and 24h were determined for the proposed wood-plastic composites. The results have shown that only a participation of up to 10% of wood shavings in the tested panels conducted to a good performance.

Key words: *wood-plastic; acrylonitrile butadiene styrene (ABS); planer shavings; water absorption (WA); thickness swelling (TS).*

INTRODUCTION

From previous research with regard to composite panels made from plastic waste, namely acrylonitrile butadiene styrene (ABS), and wood shavings resulted in the furniture manufacturing process, only four structures were selected for further testing, having mixtures ranging from a ratio of 100% ABS: 0% wood shavings to 80% ABS: 20% wood shavings (Coşereanu and Lica 2014). These structures have presented a good physical integrity and a stable structure. Water resistance, investigated in the present paper, will show if the four structures will maintain their physical integrity and their stable structure, if immersed in the water. ABS is a common thermoplastic used in many fields of applications, including furniture sector, as buffer edging for furniture components. It has a good strength, rigidity, gloss and toughness, due to the combined properties of its three components. ABS edge banding tape is applied on edges of furniture laminated wood based composite panels and has a multitude of colors and finishes of surfaces. It can be processed both on conventional edge banding machines and on automated machining centres, using hot-melt glue systems. The tape is oversized on length and widths, so that the exceeded material is afterwards processed by milling and scrapping. ABS residues thus obtained are the main raw materials for ABS-wood panels presented in this paper.

Plastic, biomass and residues from both industry and agriculture are investigated for applications in composite boards manufacture (particleboards, fiberboards, thermal insulation panels), in recent years (Nourbakhsh *et al*. 2010, Habibi *et al*. 2008, Kaimakci *et al*. 2013, Panthapulakkal and Sain, 2007). Mixtures of wood particles and plastics are known as WPCs. Due to increasing the plastic use, aged plastics and plastic wastes need to be recycled instead of filling the landfills or incinerating them. It was proved that chemicals such as furan and dioxins are produced when incinerating plastics and they cause several kinds of cancer (Nkwachkukwu *et al*. 2013). Wood waste is also an important resource for WPCs in the conditions of saving wood resources (Felix *et al*. 2013). More than that, the addition of thermoplastics to wood composites has a significant influence on the water absorption performance and on recycled and waste material utilization (Wolcott et al. 1999). Water absorption is an important issue associated with plastic-wood composite durability. Addition of thermoplastic to wooden based composites increases their ability to resist moisture intrusion. The water absorption also affects the mechanical properties and depends on the size and the rate of wood particles in the mixture of WPCs (Tamrakar and Lopez 2011). In case of cork-polymer composites with 50% of cork powder in the mixture, the obtained samples proved to have a good dimensional stability and a lower water uptake (Fernandes *et al*. 2011). Bamboo-PP composites (having 50% and 70% wood and bamboo content) registered 10% water absorption after 24 hours of immersion, and increased with the increasing of wood-bamboo content (Kartal et al. 2013). Water absorption of 18% was registered for a wood participation rate of 40% and 50% respectively for other types of WPCs (Bhaskar *et al*. 2012, Aina *et al*. 2013). An increase in geometric particle sizes and the amount of particle in WPCs resulted in a decrease in dimensional stability due to the hygroscopic characteristic of wood (Izekor *et al*. 2013).

OBJECTIVES

The present paper focuses on the determination of important physical characteristics (swelling in thickness and water adsorption) in order to make recommendations of the possible applications of these wood-plastic composites and also to investigate which structures from the total of four will maintain their physical integrity after immersed in the water. The present paper is a contribution to WPCs (wood plastic composites) field. The studied panels in this paper were manufactured from ABS residues and wood shavings resulted in the furniture production processes, by increasing the wood shavings content up to 20%. They were tested for water resistance, as a first step, in order to investigate their integrity in an outdoor environment. Having low densities (around 230kg/m^3) and porous structures, the obtained boards may be applied for thermal and acoustic insulation structures, which is the next step of research investigations.

METHOD, MATERIALS AND EQUIPMENT

The innovative WPCs were manufactured from ABS residues and wood shavings in the laboratory conditions. The raw materials resulted in the furniture manufacturing process, as residues from edge banding machine (ABS) and planner machine (wood shavings). The ABS residues were soft colored particles with lengths up to 15mm and widths below 2.5mm. Wood shavings were a mixture of beech wood and spruce wood residues (Fig. 1).

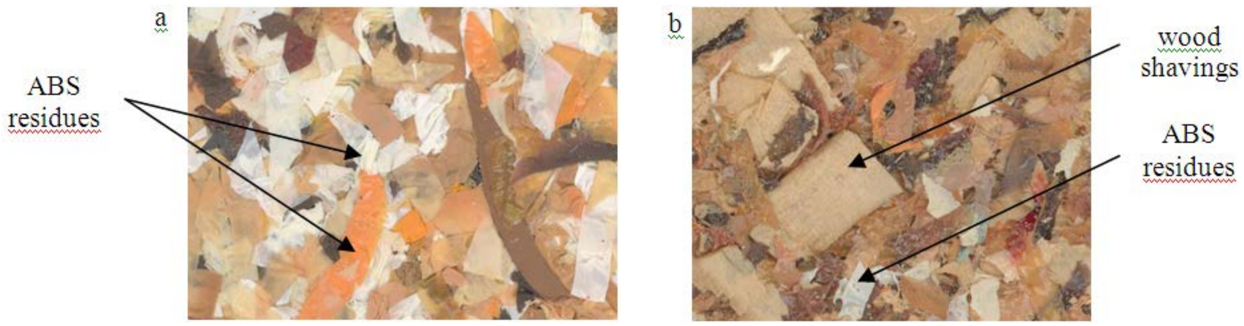

Fig. 1.
a - structure of board made from ABS 100%; b - structure of board made from mixture ABS-wood shavings.

Initially, eight types of boards were manufactured with different participation rates of wood shavings. The compactness and integrity of the board structures were considered to be the first selection criteria. After this selection, only the structures presented in Table 1 remained for next investigations. The mixture of ABS residues and wood shavings was poured into special wooden frames and hot pressed. Same technology was applied for all manufactured panels, and the processing parameters were as follows: temperature of 130ºC, pressing time of 20min, and pressure of 20 bars.

Two replicate panels were made for each board type. The panels were afterwards conditioned at 20ºC and 65% relative humidity of air for 24 hours. Each panel was cut to get five WA/TS specimens (50mm x 50mm), as seen in Fig. 2a. Five specimens from each panel were placed under the rails of the special device shown in Fig. 2b and submerged in clear water at a temperature of 20ºC for 24 hours.

The test for the determination of water resistance was conducted according to EN 317:1993. The results of the test are expressed by the calculated mean value (in %) of thickness swelling (TS) and water absorption (WA) respectively.

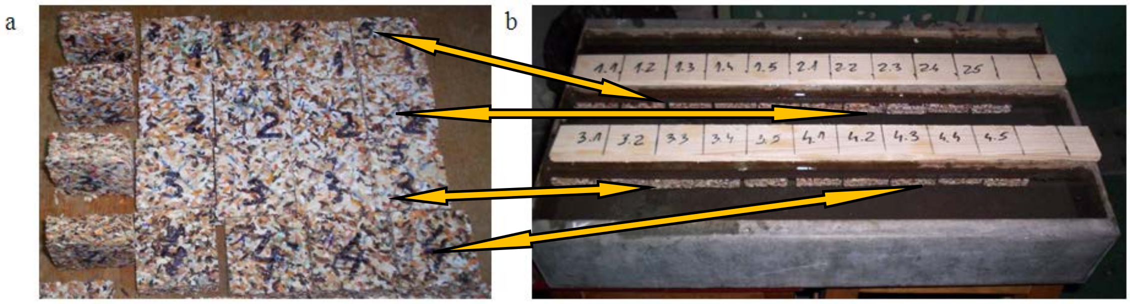

Fig. 2.
a – five WA/TS specimens cut from each board ; b – specimens submerged into the water.;

Thickness swelling (TS)

Thickness of the specimens was measured at the point where the two diagonals intersect using a caliper with 0.01 mm accuracy. The thickness was measured for each specimen before immersion, and after 1 hour, 2 hours and 24 hours of immersion, respectively. The calculation formula of the thickness swelling (TS), expressed in %, is as follows:

$$TS = \frac{T - T_0}{T_0} \cdot 100 \tag{1}$$

Where:
T = thickness measured after immersion, in mm;
T_0 = thickness measured before immersion, in mm;

TS was calculated and reported after 1 hour, 2 hours and 24 hours of immersion. After 24 hours of immersion, the specimens were taken out from the water, conditioned in normal environment and the thickness was re-measured in the center point after another 120 hours.

Water absorption (WA)

The mass of the specimens was also measured prior the test, after 1 hour, 2 hours and after 24 hours of immersion. Water absorption (WA) was calculated with the following equation (2):

$$WA = \frac{M - M_0}{M_0} \cdot 100 \tag{2}$$

Where:
M = mass of the sample after immersion, in g;
M_0 = mass of the sample before immersion, in g;

The mass was also weighed after 120 hours from the moment of taken out the specimens from the water.

RESULTS AND DISCUSSIONS

As seen in Fig. 3a, the average values of thickness swelling (TS) were lower for Panels 1, 2 and 3. Instead, Panel 4, which had a higher content of wood shavings (20%), suffered a more visible thickness increasing because of the wood swelling.

Compared to the values found in the literature (Tamrakar and Lopez 2011, Kartal *et al.* 2013, Bhaskar *et al*. 2012, Aina *et al*. 2013) for WPCs, which were up to 18% after 209 days of immersion, the water absorption percentages in case of the investigated panels of the present study where considerably higher (between 33% and 245%), as seen in Fig. 3b. The differences are significant, considering that the WPCs referred to in the literature, had a wood participation rate of maximum 50%. The explanation is linked to the porous structure of the investigated panels, having low densities (around 200kg/m3), which allowed the penetration of water into the gaps filled before with air. When WPCs came in contact with water, the wood shavings absorbed water and started to swell, weakening the links formed in the polymer matrix, and reducing their resistance. The micro-

PRO LIGNO
www.proligno.ro
Vol. 10 N° 4 2014
pp. 35-39

cracks resulted because of the internal stresses facilitated water intrusion into the core of the structure. Thus, the amount of water consequently increased during the 24 hours of water immersion, as seen in diagram from Fig. 3b.

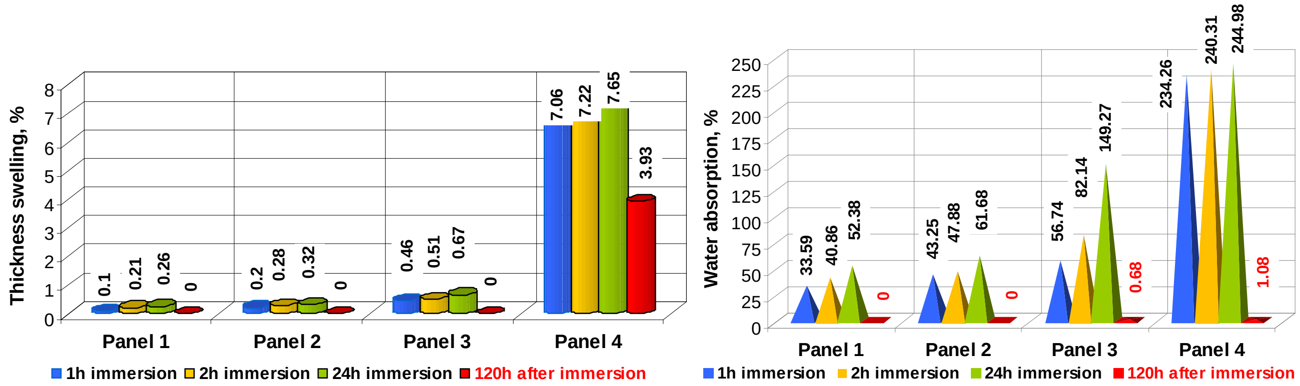

Fig. 3.
(a) thickness swelling (TS); (b) water absorption (WA).

After 24 hours of water immersion, the wet specimens were allowed to dry for 120 hours. As the measurements shown, only the structures of Panel 1 and Panel 2 recovered their initial stages, the water being completely removed after 120 hours of drying. Because of the higher content of wood shavings, Panels 3 and 4 suffered important structure modifications of the polymer matrix, by cracking and yielding. Even after 120 hours of drying, the specimens couldn't recover their initial thickness and mass.

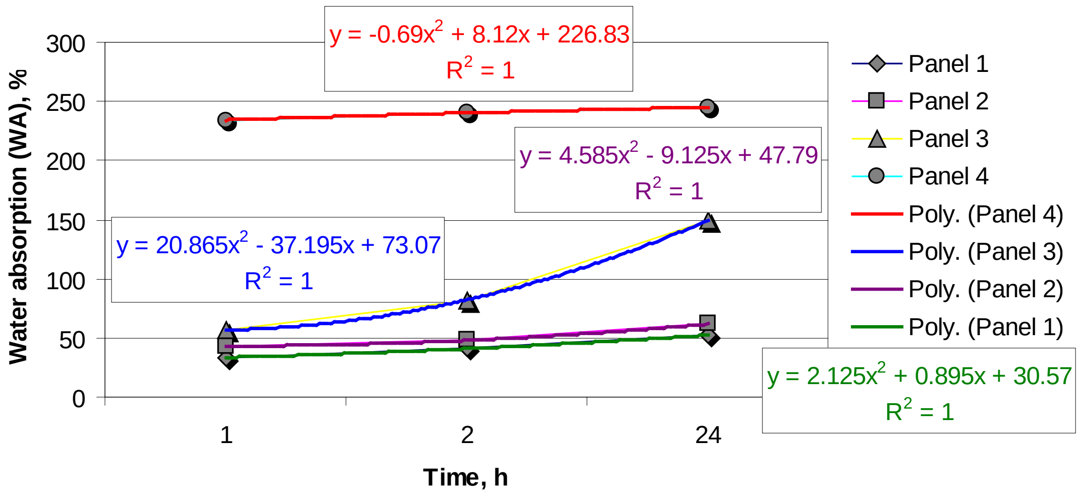

Fig. 4.
The polynomial function trends for investigated panels with regard to water absorption.

The curves in the diagram in Fig. 4 show the dynamic characteristic of the swelling phenomena in time, for the investigated panels. A moderate dynamic curve resulted for Panels 1, 2 and 4, but a higher dynamic trend was registered for Panel 3. With regard to the water absorption results, only Panels 1 and 2 registered low values.

CONCLUSIONS

The investigations on the water resistance of the innovative panels made from ABS and wood residues have shown that the participation rate up to 10% of wood shavings does not modify the internal structure of the material subjected to water immersion. A participation rate that exceeds this percentage produces residual damages in the material structure when immersed into the water. These materials once exposed to water or moist environment, will easier allow the water to penetrate deeper the next time, when the produced damages create pathways for moisture intrusion. Further research can be done on structures such as Panel 1 and Panel 2, which proved to have a good performance in water and moist environment.

REFERENCES

Aina KS, Osuntuyi EO, Aruwajoye AS (2013) Comparative Studies on Physico-Mechanical Properties of Wood Plastic Composites Produced from Three Indigenous Wood Species. International Journal of Science and Research (IJSR), India Online 2(8):226-230.

Bhaskar J, Haq S, Pandey AK, Srivastava N (2012) Evaluation of properties of propylene-pine wood Plastic composite. J. Mater. Environ. Sci. 3(3):605-612.

Coşereanu C, Lica D (2014) Wood - Plastic Composites From Waste Materials Resulted In The Furniture Manufacturing Process, PRO LIGNO, 10(2):26-33.

Felix JS, Domeno C, Nerin C (2013) Characterization of wood plastic composites made from landfill-derived plastic and sawdust: Volatile compounds and olfactometric analysis. Waste Management 33:645-655.

Fernandes EM, Correlo VM, Chagas JAM, Mano JF, Reis RL (2011) Properties of new cork-polymer composites: Advantages and drawbacks as compared with commercially available fibreboard materials. Composite Structures 93:3120-3129.

Habibi Y, El-Zawawi WK, Ibrahim M, Dufresne A (2008) Processing and characterization of reinforced polyethylene composites made with lignocellulosic fibers from Egyptian agro-industrial residues. Composites Science and Technology 101:2525-2528.

Kaimakci A, Ayrilmis N, Gulec T (2013) Surface Properties and Hardness of Polypropylene Composites Filled With Sunflower Stalk Flour. BioResources 8(1):592-602.

Izekor DN, Amiandamhen SO, Agbarhoaga OS (2013) Effects of geometrical particle sizes of wood flour on strength and dimensional properties of wood plastic composites. Journal of Applied and Natural Science 5(1):194-199.

Kartal SN, Aysal S, Terzi E, Yilgor N, Yoshimura T, Tsunoda K (2013) Wood and Bamboo-PP Composites: Fungal and Termite Resistance, Water Absorption, and FT-IR Analyses. BioResources 8(1):1222-1244.

Nourbakhsh A, Ashori A (2010) Wood-plastic composites from agro-waste materials: Analysis of mechanical properties. Bioresource Technology 2525:2528-101.

Nkwachkukwu OI, Chima CH, Ikenna AO, Albert L (2013) Focus on potential environmental issues on plastic world towards a sustainable plastic recycling in developing countries. International Journal of Industrial Chemistry 4:34.

Panthapulakkal S, Sain M (2007) Agro-residue reinforced high-density polyethylene composites: Fiber characterization and analysis of composite properties. Composites: Part A 38:1445-1454.

Tamrakar S, Lopez-Anido RA (2011) Water absorption of wood polypropylene composite sheet piles and its influence on mechanical properties. Construction and Building Materials 25:3977-3988.

Wolcott MP, Englund KA (1999) Technology Review of Wood-Plastic Composites 33-rd International Particleboard/Composite Materials Symposium proceedings, pp. 103-111.