PROPERTIES OF WOOD PLASTICS NANO-COMPOSITES MADE OF AGRICULTURAL RESIDUES AND URBAN RECYCLED POLYMER MATERIAL

Nourbakhsh Habibabadi , Amir [1]*
Mojgan Kouhpayehzadeh Esfahani[2]

[1] Department of Wood and Paper Science, Research Institute of Forests and Rangelands (RIFR), Associate Professor, Tehran, Iran
* Corresponding author (dr.amirnourbakhsh@gmail.com)
[2] Azad University of Varamin, Pishva Branch
Assistant Professor,
P.O. Box 33817-74895, Iran

Keywords: *Recycled, Wood, Polymer*

ABSTRACT

This study investigated the feasibility of using recycled high density polyethylene (rHDPE), polypropylene (rPP), and five types of cellulosic residues fibers (bagasse, corn stalk, rice straw, sunflower, and canola stem) and three levels of nano/materials (carbon nanotubes, nano silica, and nanoclay) for manufacturing experimental composite panels. To chemically bind the wood/polymer fibers, chemicals, and reinforcement, coupling agent was used. Extruders and hot presses were used to fabricate the composites. The effects of the wood fibers, nano/materials, and recycled polymers, on the tensile and flexural of wood–fiber plastic nano/composites were studied.

It was found that composites with rHDPE provided moderately superior properties compared with rPP samples. Regarding the use of agricultural residues in the production of wood-plastic composites, in general, the results have shown that the addition of agricultural residues in several types of wood plastics nano-composites has significantly improved the bending and tensile properties. Among them, the bagasse has a significant advantage over other lignocellulosic materials. The use of recycled polymers, agricultural residues, and using nano-silica has shown the best results in strength properties. In general, the results showed that using agricultural fiber residues as reinforcement in wood/plastic nanocomposites improved the mechanical properties. Based on the findings in this work, recycled materials can be used to manufacture value-added panels without having any significant adverse influence on the properties.

1 INTRODUCTION

The growing concern over the management of plastic waste and the high demand for wood-based products has led to the development of wood-plastic composites. Agricultural residues, which are abundantly available, can be used as a source of lignocellulose fibers in the production of these composites. The use of recycled polymers and nanomaterial is also a promising approach to enhance the mechanical and physical properties of the composites.

The possibility of using recycled materials in the development of nano-composites is very attractive, especially with respect to the large quantity of wood fiber/plastic waste generated daily [2]. Advantages associated with bio-composite products include lighter weight and improved acoustic, impact, and heat reformability properties – all at a cost less than that of comparable products made from plastics alone. In addition, these composites may possibly be reclaimed and recycled for the production of second-generation composites. Municipal solid waste (MSW) generated each year contains potentially useful and recyclable materials for composites. Interest is high for using MSW in the composites, thus providing cost and environmental benefits. The possibility of using municipal solid waste (MSW) in the development of composites is very useful, especially with respect to the large quantity of plastic waste generated daily. Hence, the development of new value-added products, to utilize the recovered plastics, is assuming greater importance. Adding recycled wood fibers to waste plastics renders the resulting composites viable from both the mechanical properties and the environmental points of view. Besides, bio-composite products may be reclaimed and recycled for the production of second-generation composites. [3]

The aim of this study was to investigate the feasibility of using recycled high density polyethylene (rHDPE), polypropylene (rPP), and agricultural residues fibers for manufacturing wood-plastic Nano-composites.

The aim of this study was to investigate the feasibility of using recycled high density polyethylene (rHDPE), polypropylene (rPP), and agricultural residues fibers for manufacturing wood-plastic Nano-composites. The effects of these materials on the mechanical properties of the composites, specifically tensile and flexural strength, were studied. The study utilized an experimental approach where extruders and hot presses were used to fabricate the composites. Five types of cellulosic residues fibers (bagasse, corn stalk, rice straw, sunflower, and canola stem), three levels of nanomaterial (carbon nanotubes, Nano silica, and Nano clay), and coupling agent were used to chemically bind the wood/polymer fibers, chemicals, and reinforcement. The mechanical properties of the composites were then analyzed.

Materials and Methods :

The effects of these materials on the mechanical properties of the composites, specifically tensile and flexural strength, were studied. The study utilized an experimental approach where extruders and hot presses were used to fabricate the composites. Five types of cellulosic residues fibers (bagasse, corn stalk, rice straw, sunflower, and canola stem), three levels of nanomaterial (carbon nanotubes, Nano silica, and Nano clay), and coupling agent were used to chemically bind the wood/polymer fibers, chemicals, and reinforcement. The mechanical properties of the composites were then analyzed.

Composite preparation:

In the first stage, the raw materials were premixed based on formulations before being fed into the extruder. The compounding of the blends was performed in a co-rotating twin screw extruder (Collin). The barrel temperatures of the extruder were controlled at 165, 175, 185 and 190 Celsius for zones 1, 2, 3 and 4, respectively, while the temperature of the die was held at 190. The melt temperature was kept 190 to prevent wood degradation, and screw speed was set at 60 rpm. The extruded strand was passed through a water bath and granulated. In the second stage, the cooled extrudate in the form of strands were injection molded at 190 to produce standard ASTM specimens.

After conditioning (23 ± 2 C, 50 ± 5% RH), all the specimens were tested following ASTM standard D638 for tensile properties, ASTM D790 for flexural properties and D256 for notched Izod impact strength. [1] Tensile and bending tests were conducted using an Instron Universal Testing Machine (model 1186) at speeds of 1.5 and 2 mm/min, respectively. A pendulum impact tester (Zwick 1446) was used for the Izod impact test. For each treatment level, five replications were conducted. [1]

Studies on the morphology of the composites were carried out using a TESCAN model WEGA-II scanning electron microscope (SEM)

Results:

In this work, the potential of using recycled wood fibers and recycled plastics and nano-materials for making wood-plastic composites (WPCs) was examined. The effect of fibers and recycle polymer loading, and coupling agent addition on the mechanical properties and dimensional stability was also investigated.

This study studied the feasibility of using recycled high density polyethylene (rHDPE), polypropylene (rPP), five types of cellulosic residues fibers (including bagasse, corn stalk, rice straw, sunflower and canola stem), and three levels of nano/materials (carbon nanotubes, nanosilica, and nanoclay) for manufacturing experimental composite panels.

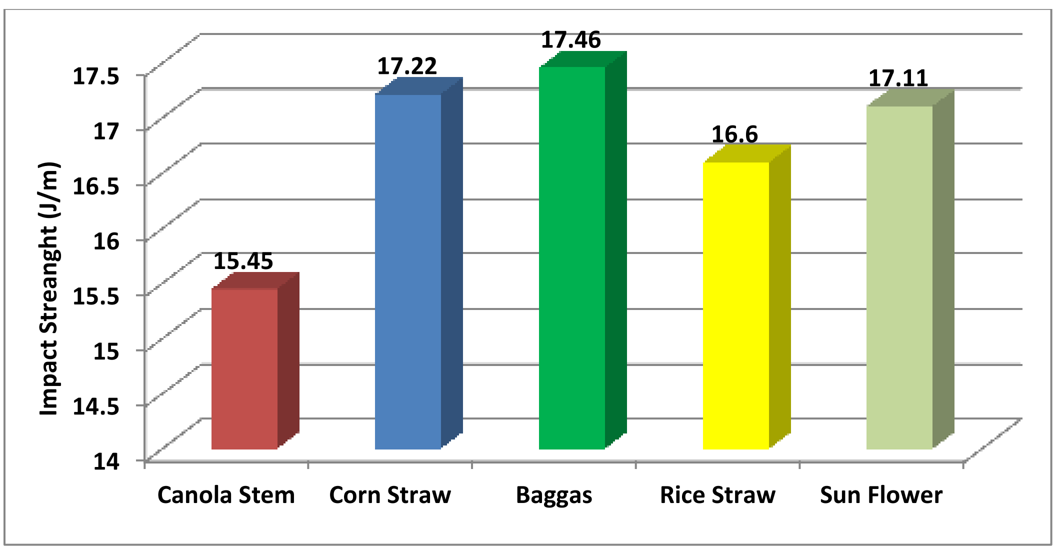

Figure 1. The Independent Effect of Agricultural Residues on the Impact Strength of wood-plastic nanostructures

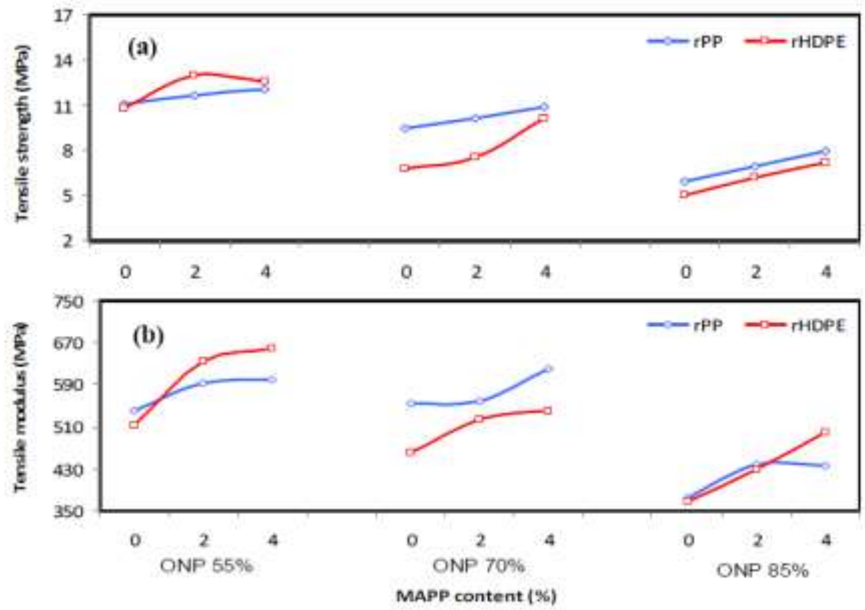

Figure 2. Comparisons on Tensile strength rPP and rHDPE residues in wood plastics Composites.

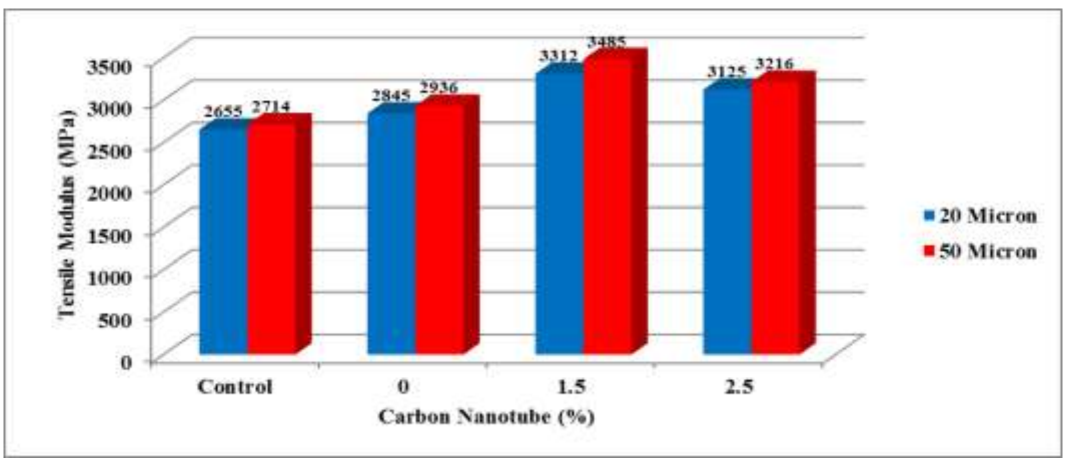

Figure 3. Tensile modulus of composites made with various MWCNT loading.

To chemically bind the wood/plastic composites, chemicals and reinforcement, coupling agent was used. Extruders and hot presses were used to fabricate the composites.

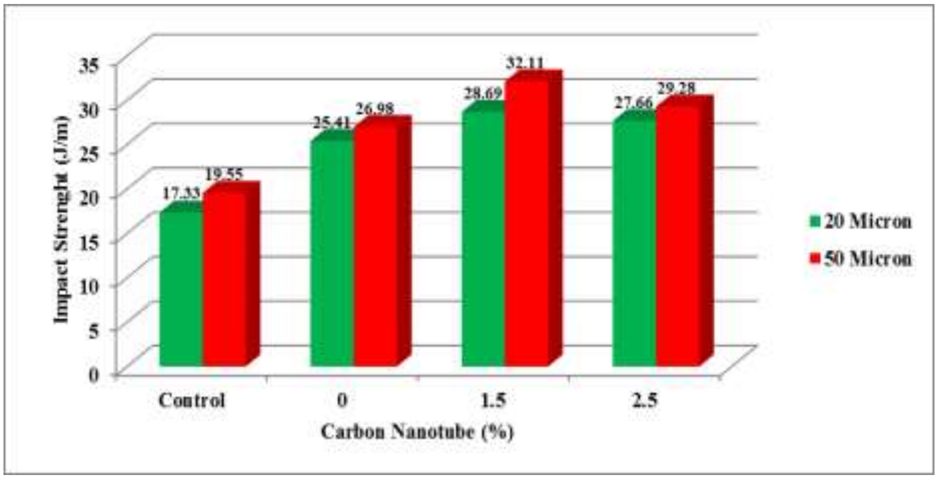

Figure 4. Impact strength of composites made with various MWCNT loading

Morphology Characteristics:

Through SEM study, the distribution and compatibility between the fiber and the matrix could be observed. The tensile fracture surfaces of the composites treated with1.5 and 2.5 wt% MWCNT are shown in Fig 5 . In the case of the composite made with the 1.5 wt% MWCNT and 50 micron of MCC (Fig. a), there is no separation of the fibers from the matrix and a very good interaction between the components can be inferred from the image. The strong adhesion that is observed at the interface has been already discussed in mechanical properties. As seen from Fig. b, there are some voids where the fibers have been pulled-out. When stress is applied it causes the fibers to be leave the matrix easily and makes gaping holes. The presence of these voids means that the interfacial bonding between the fiber and the matrix polymer is weak.

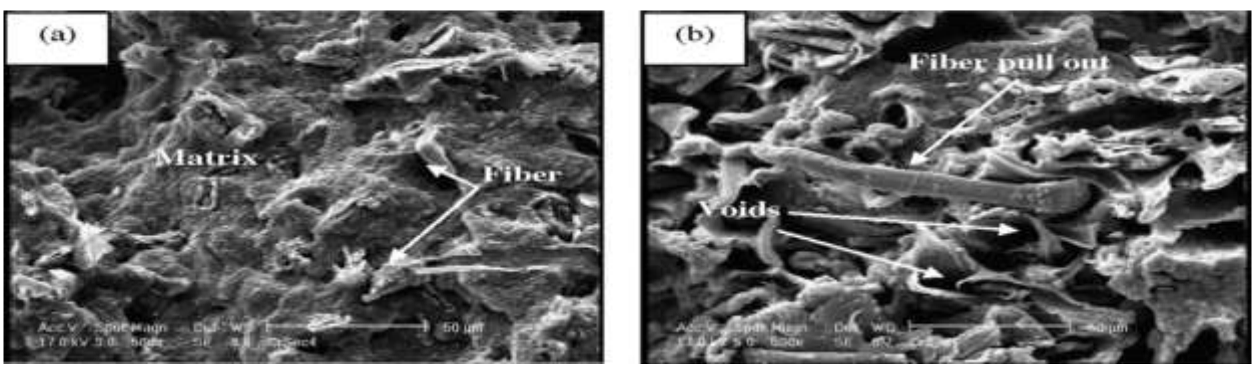

Figure 5. The tensile fracture surfaces of the composites treated with1.5 and 2.5 wt% MWCNT

REFERENCES

[1] Annual Book of ASTM Standards,. American Society for Testing and Materials, 100 Barr Harbor Dr., West Conshohocken, PA 19428, United States 1999

[2] Ashori, A., Municipal solid waste as a source of lignocellulosic fiber and plastics for composite industries. Polymer–Plastics Technology and Engineering Journal 47 (8), 741–744.2008

[3] Nourbakhsh, A., Ashori, A., & Kazemi Tabrizi, A.. Characterization and biodegradability of polypropylene composites using agricultural residues and waste fish. Composites Part B: Engineering, 56, 279-283. 2014