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AGRICULTURAL WASTE RECYCLING IN COMPOSITE MATERIALS PLATES

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Abstract: *In recent years, the interest in using natural fibers in bio-composite materials has grown because they are non-toxic, low cost and easy to recycle. Alternative agricultural fibers that seem most appropriate and available in Romania are cereal straw, rape straw, corn stalks, cotton stalks, rice husks, rice straw and sunflower hulls and stalks.*
In this paper we present the effects of different types of fiber treatments on mechanical properties of composites materials made from agricultural residues.
Keywords: *agricultural residues, bio-composites, boards, resin, mechanical properties.*

1. INTRODUCTION

The interest in natural fiber-reinforced polymer composite materials has increased dramatically in recent years [1]. Amount of available agricultural wastes that result depends on the region and country, while climate and weather also affect yield and quality [2]. Using agricultural wastes for industrial purposes is much more environmentally friendly practice than many residues available currently in use. Until recently, many farmers disposed of agricultural wastes by burning or land filling them. In fact, more than 1 million tons of California straws were burned every autumn from the start of this decade. Researchers have estimated quantities a 56,000 tons of carbon monoxide annually This practice is unfriendly to the environment, but also an irresponsible approach to the multitude of lignocelluloses waste resources [3].
These wastes constitute an annual source of biomass that can be used for obtaining composite materials and represents an alternative to wood for producing composites such as fiberboard. Bio-fibers have many advantages such as renewability, recyclability, biodegradability, low density and low cost.
Rapidly increasing global production boards and the lack of wood, were required to find new sources of raw materials, which correspond to the technically and economically for this production. Attention was particularly focused on agricultural residues such as cereal straw, rape straw, corn stalks, cotton stalks, rice husks, rice straw, and sunflower hulls and stalks whose strains are suitable for producing fiberboard with the use of both ureo-formaldehyde and phenol-formaldehyde adhesives.
The majority of fiber crops is seasonal and in some regions typically harvested annually over a 100-day period. For efficient fiberboard production, the storage of adequate quantities of raw material should be considered. Climatic conditions, protection from moisture and control of fungal infestation has to be taken into account when storing the product [2].
Several studies were conducted to use the agricultural residues such as cotton stalks [4, 5], sunflower stalks [6], rice husks [7], rape straw [8], flax [9, 10], and wheat straw [11] have been studied as reinforcement in composites. These materials are annually renewable resources. Therefore, they are very powerful on availability, compared, for example, with wood.
The abundance of natural fibers together with the ease of their operability is an attractive feature, which makes it an appropriate substitute for synthetic fibers that are potentially toxic [12].
The aim of this study was to examine the possibility of making composite materials by recycling agricultural wastes, thus solving a serious problem of environmental pollution caused by these industrial and agricultural wastes production. Using these agricultural wastes could open new markets and improve the rural agriculture based economy.

2. EXPERIMENTAL PROCEDURES

2.1. Materials

Wheat straw and maize stalks were the sources of fibers used in this study. Wheat straw and maize stalks were collected from local farmers and then chopped in a knife mill Grindomix GM 200. Chemical composition of fibers from these sources is shown in Table 1 [13]. However, it was realized that the proportion of these components in a fiber depends on the age and source of the fiber. In the production of experimental panels, polyester resins ortophtalic Lerpol TIX 3603 was used as binder. Properties of the matrix resin are given in Table 2.

Table 1: Chemical compositions of raw material

Raw material	Cellulose [%]	Lignin [%]	Inorganic compounds [%]	Silica [%]
Wheat straw	31 – 45	16 – 19	5 – 9	3 – 7
Maize stalks	32 – 35	16 – 27	5 – 6	3 – 5

Table 2: Resin characteristics

Properties	Value	Measurement unit
Brookfield viscosity	400 ± 50	cPs
Density	1110 – 1120	kg/m^3
Monomer content	38 ± 1	%
Gel time at 25 °C	10’00’’ ± 2’00’’	minutes
Exothermic peak	190 ± 2	°C
Heat distortion temperature (HDT)	90 – 95	°C

2.2. Fiber surface modification

The fibers were first placed in solution of potassium hydroxide (KOH) with 5 % concentration for 3 h at room temperature. Afterward, the alkalized fibers were washed with distilled water, followed by neutralization with 20 ml of acetic acid ($C_2H_4O_2$) solution. Wheat straw and maize stalks were then washed with distilled water again and dried at 105 °C for 24 h.

3. RESULTS AND DISCUSSION

3.1 Fiber surface morphology

Scanning electron microscopy provides an excellent technique for examining the surface morphology of untreated and treated natural fibers. A JOEL JSM5510 LV Scanning Electron Microscope was used to observe the surface morphology of wheat straw and maize stalks before and after treatments. All samples were coated with gold before examination. It is expected that the surface morphology of untreated fiber will be different to that of treated fiber particularly in terms of their level of smoothness and roughness. Therefore, studies of the fiber surface topography could provide information on the level of interfacial adhesion that would exist between the fiber and the matrix later when used as reinforcement fiber with and without treatment. Figure 1 (a) and 1(b) shows the SEM micrograph of untreated wheat straw and maize stalks, in both figures, there are still a lot of impurities. SEM micrographs show an improvement in surface morphology after applying KOH treatment. The improvement can be seen in figure 1 (c) and (d) shows that using 5 % KOH treatment cleans the fiber surface of a large amount of impurities.

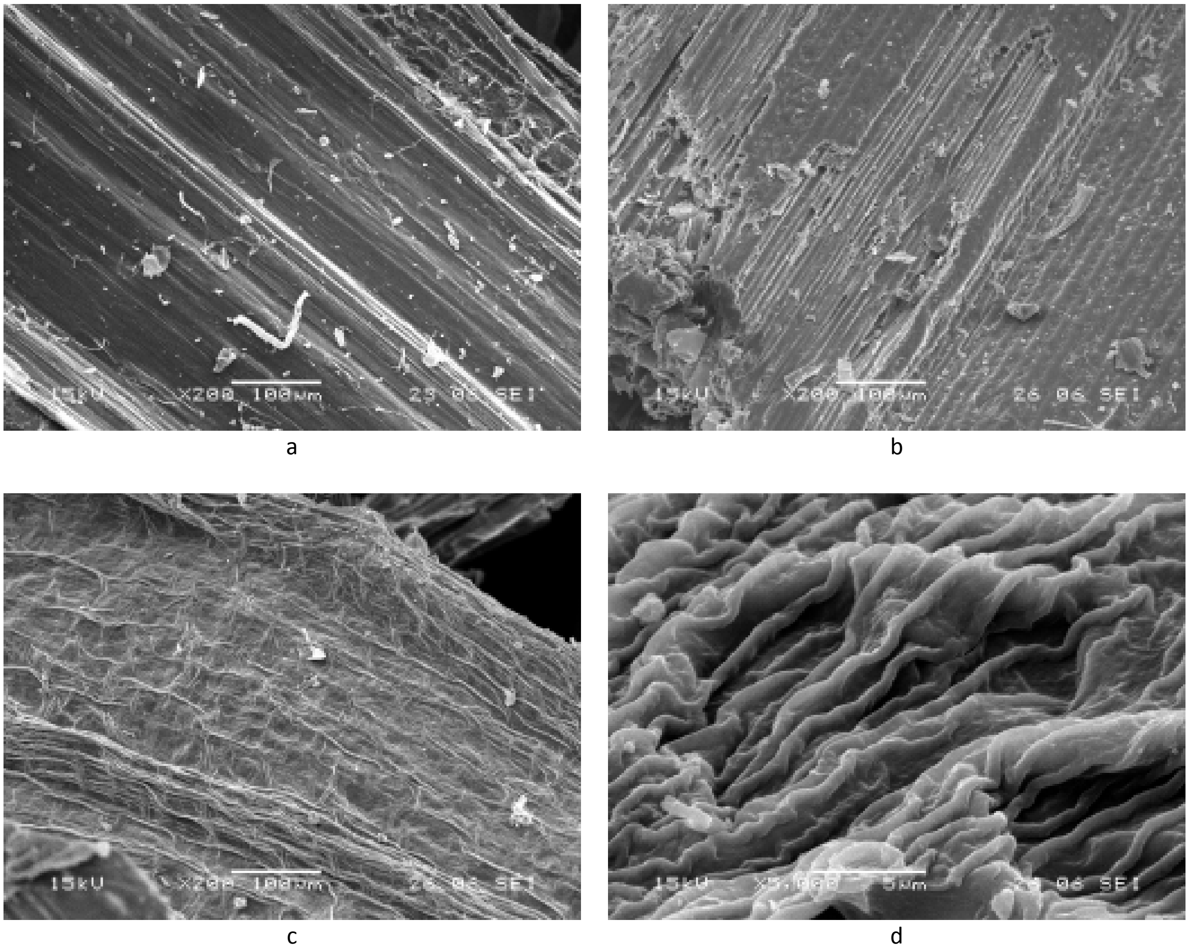

Figure 1: SEM micrograph of (a) untreated wheat straw, (b) maize stalks and (c and d) mixture wheat straw and maize stalks treated with 5 % KOH

Table 3: Water absorption

Sample	Plate type		Initial	After 3 hours	After 48 hours	After 144 hours
1	wheat straw and maize stalks + epoxy resin	Weight [g]	4,45	4,49	4,59	4,73
2	wheat straw and maize stalks + epoxy resin	Weight [g]	4,51	4,55	4,69	4,72
3	PAL board	Weight [g]	6.02	-	9.75	-
4	PAL board	Weight [g]	5.86	-	9.82	-

4. CONCLUSION

The use of other renewable resources such as agricultural residues in the production of composite materials has recently been considered attractive both from economical and environmental point of view. Wheat straw and maize stalks have been treated with 5 % KOH. The morphological changes were examined using scanning electron microscopy. The chemical treatments can increase the interface adhesion between the fiber and matrix resin. Therefore, chemical treatments can be considered in modifying the properties of natural fibers. Because the chemical treatments clean the fibers we can observe a less water absorption of the finite composite board and a better comportment in humid environment.

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REFERENCES

[1] Xue Li, Tabil L. G., Panigrahi S., Chemical Treatments of Natural Fiber for Use in Natura Fiber-Reinforced Composites: A Review, *Journal of Polymers and the Environmental*, vol. 15, 2007, pp. 25 – 33.

[2] Markessini E., Roffael E., Rigal L., Paneles from Annual Plant Fibers Bonded with Urea-Formaldehyde Resins, 31st International Particuleboard/Composite Materials Symposium, pp. 147-160.

[3] Clancy-Hepturn, M., Agricultural Residues: A Promising Alternative to Virgin Wood Fiber. Issue in Resources Conservation, Briefing Series No. 1 Resources Conservation Alliance. Washington, 1998, DC.

[4] El-Mously H.I., Use of Agricutural Residues în Industry: A Case Study from Egipt, *International Conference Challenges for Science and Engineering in the 21st Century*, Stockhlom, Sweden, 14 – 18 June 2000.

[5] Kargarfard A. and Nourbakhsh A., Utilization of grape prunings residues in middle layer of particleboard*, Pajouhesh & Sazandegi*, Vol. 78, 2008, pp. 186 – 191.

[6] Bektas I., Guler C., Kalaycioglu H., Mengeloglu F. and Nacar M., The Manufacture of Particleboards using Sunflower Stalks (*helianthus annuus L.*) And Poplar Wood (*Populous alba L.*), *Journal of Composite Materials*, Vol. 39, Issue 5, 2005, pp. 467 – 472.

[7] Johnson A. C., Yunus N., Particleboards from Rice Husk: A Brief Introduction, School of Environmental Engineering, Universiti Malaysia Perlis.

[8] Dziurka D., Mirski R., Lecka J., Properties of boards manufactured from rape straw depending on the type of the binding agent, *Electronic Journal of Polish*, Vol.8, Issue 3, 2005.

[9] Cantero G., Arbelaiz A., Llano. – Ponte R and Mondragon I., Effects of Fiber Treatment on Wettability and Mechanical Behaviour of Flax/Polypropylene Composites, *Composites Science and Technology*, Vol. 63, 2003, pp. 1247 – 1254.

[10] Arbelaiz B., Fernández J.A., Ramos I. and Mondragon I., Thermal and Crystallization Studies of Short Flax Fiber Reinforced Polypropylene Matrix Composites: Effect of Treatments, *Thermochimica Acta*, Vol. 440, 2006, pp. 111 – 121.

[11] Panthapulakkal S., Zereshkian A., Sain M., Preparation and Characterization of Wheat Straw Fibres for Reinforcing Application in Injection Molded Thermoplastic Composites, *Bioresource Technology*, Vol. 97, 2006, pp. 265 – 272.

[12] Pothan, L.A., Thomas, S., Groeninckx, G., 2006. The role of fibre/matrix interactions on the dynamic mechanical properties of chemically modified banana fibre/polyester composites, *Composites Part A* vol. 37, 2006, pp. 1260 – 1269.

[13] Mantanis G. I., Koukos P. K., Agricultural lignocellulosic residues in Greece: Estimation and prospects for rational utilization, Forest Research Institute Laboratory of Wood Technology Vassilika, GR – 570 06, Thessaloniki Macedonia, Greece, pp. 1 – 10.