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Mechanical behaviours of composite material manufactured with beef horn sheath's adhesives

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Abstract
WP/HP and HP/HP is a new composites, manufactured each with a Keratin resin extracted from horn sheaths and reinforced respectively with wood particles and horn sheaths particles, whose size varies from 125 to 625 µm were characterized. The best physicals and mechanicals properties were obtained at 225 µm. The values of the thickness swelling ratio, density, maximum forces and resistances, modulus of elasticity , modulus of resistance in bending break and the internal bond of WP/HP and HP/HP (at 225 µm) are respectively (21% for 2H and 22.4% for 24 H, 600kg/m^3, 432000Pa, 1750 MPa ,22.8 MPa et 0.42 MPa) and (17% for 2H and 19% for 24 H, 750kg/m^3, 340000Pa, 1590 MPa ,20.2 MPa et 0.34 MPa).The WP/HP are stronger than HP/HP and can be used in a dry environment. The resin developed can be used in wood industry one.

Keywords: *bio composites, Keratin, particleboard, horn sheaths, used in wood industry.*

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I. INTRODUCTION

Their flesh, which is consumed by the people, makes it easy to recover their horns in slaughterhouses throughout the country. They are constituted of a structural molecular called keratin that has very different sizes and shapes, however several discoveries of utilization objects by artisans such as buttons, salad servers, spoons, hair combs, bracelets, pipes, canes, knife handles, chairs and beds **[5]** have been realized. Nowadays, farmers use horns as fertilizer to fertilize the soil, fattening fruit trees **[3]** that which pollutes the environment. The environmental constraints of sustainable development, regulatory changes in terms of recycling, in terms of hygiene and safety have pushed industrialists and researchers to develop new composite materials from natural resources. It is in this perspective that the mechanical properties of horns and hooves have been studied and has shown that flattened cells can effectively resist nucleation and crack propagation **[7]**, the microstructure of the mechanical properties of strain and elasticity has showed the horn to a lamella-like structure stacked with intercalated tubules and this leads to an overall transverse porosity of 7%, the compression of the tubules aids in the absorption of energy .Horn anisotropy is confirmed as well as energy dissipation **[14]**, keratin extracted from oxen hooves and a biocompatible material to promote cell attachment and has high thermal stability **[15]** as well as behavior by numerical analysis and image correlation **[8]** The rheology of horns and hooves has made it possible to determine the mechanical characteristics of a machine that makes it possible to saw and grind these natural products directly). Research continued on the valorization of this bio-waste reduced to particles and used as a biological load for the manufacture of composite materials with synthetic matrices including polypropylene for use in automobiles, computers and construction, **[12]**; the epoxy used as brake pad and clutch disc but the horns were not used as a matrix in the manufacture of composite materials.

Research into the solutions of less polluting and less toxic materials has been a focus of interest in recent years, as particle board made from glues of biological origin (vegetable and animal) such as gelatin, lignin, tannin reinforced kenaf stem **[6]** and tannin extracted from the reinforced woodchips aningre **[11]** were developed with low formaldehyde content less than 5% and found satisfactory results consistent with Particle board used in a dry environment, this substance being carcinogenic **[4]** allows us to find alternative solutions, that of completely eliminating these synthetic products. The work done using kapokier sawdust particles with the tanned powder of the pod pod **[13]** was developed without the addition of toxic products or volatile gas to address this concern.

It is in this order of thought that our work on the production of a 100% biodegradable material is based on exploiting the horns of cattle as a matrix and the particles of wood sawmills resulting from joinery work as reinforcement. This answers the question of production of materials without emission of toxic gases dangerous for man and his environment. The physical and mechanical properties were determined and compared to the reference values of the particle boards.

II. MATERIALS AND METHODS

a. Preparation of raw materials

Beefs horns are collected at the slaughterhouse of Maroua, and washed with water and caustic soda to move the fat, then they were powdered after dried at room temperature during 15 days.

b. Preparation of adhesives

Mix 10 g of keratin powdered in 7.14 g of 35% Na 2 S, 1 g of pure NaOH and 91.86 g of water, next add this mixture to a flask and reflux at 50 ° C during 3 hours, then we obtain a mixture yet to use as adhesive.

c. Particleboards preparation

Two particleboards manufactured with the adhesive described above were studied particularly the WP/HP and HP/HP. The first one was manufactured using wood particles as as reinforcements and second, use beef's horns particles.

In fact, the manufacturing of these particleboards (350mmx300mmx13mm of size) consist by mixing the sample of each particles with 10% of the adhesive developed above using a mixer for about 3 minutes. The mixture of each sample was compacted in a press in three phases like 32 kg/cm^2 , 15 kg/cm^2 and 5 kg/cm^2 during 5 min, 5 min and 3 min respectively, at 180 ° C. Each sample of particleboard was cut at a size for physicals and mechanicals testing.

2.1 Mechanical properties

a. Resistances and forces maximum

The 120 mm x 20 mm x 12 mm samples were cut according to EN 326-1. The three - points bending tests were carried out using a dedicated device branded JFC-H5KT, with digital data acquisition. The Maximum forces and resistances were recorded at a speed of 3 mm / min. Before each mechanical test, the samples were conditioned in a condenser for 24 hours at 20° C.

b. Modulus of Elasticity (MOE) and Resistance in bending (MOR)

The modulus of elasticity (MOE) and the resistances in bending (MOR) are determined according to the NF-EN 310 standard. The MOE and MOR values retained are corresponding to the average of 10 samples in each case.

$$MOE = \frac{L^3}{4xbxe^3} x \frac{F_2 - F_1}{a_2 - a_1}$$

$$MOR = \frac{3xL}{2xbxe^2} xF_r$$

Fi: the measured force for a displacement ai

Fr: the load measured at break

L: distance between the points of support

b: width of the specimen

e: thickness of the test piece

c. Internal bond of particle board

The internal bonds (IB) of each particle board were made on 50 mm × 50 mm × 12 specimens subjected to traction perpendicular to the faces according to the NF EN 319 standard on 10 test pieces.

2.2 Physical properties

a. Thickness Swelling and Water absorption

The rate of swelling in thickness (TS) and the rate of water absorption (WA) are determined according to standard NF-EN 317 on 10 test pieces of dimensions 50mm × 50mm × 12mm. The thicknesses and masses are initially measured using respectively a calipers and scales, then, each sample are immerged in water during 2 and 24 hours. After having withdrawn each sample in water, they are dewatered and placed in a refrigerant during 60 minutes.

$$TS = \frac{t_f - t_i}{t_i} x100$$

ti: thickness of the specimen before immersion
tf: thickness of the specimen after immersion

$$TA = \frac{m_f - m_i}{m_i} x100$$

mi: initial mass of the specimen before quenching

mf: final mass of the test piece after quenching

b. apparent density

The density is determined according to the requirements of standard NF-EN 323 on specimens of dimensions 50mm x 50 x 12 mm. The apparent density is the average of the densities measured on the test pieces of each formulation. This apparent density is the ratio of the mass of each specimen by its volume.

III. RESULTS AND DISCUSSION

3.1. Mechanical properties

The curves of Figure 1 below show the variation of the resistance of particleboards WP/HP and HP/HP depending the sizes of particles. From these curves, we deduce that the maximum resistances values of WP/HP and HP/HP are respectively 432000 Pa and 340000 Pa. These maximum values correspond to the size 225 µm. This could be justified by their Modulus of Elasticity. Thus, the Modulus of Elasticity of the wood used and particularly the bibinga one is greater than the horn one (3.29 Gpa). these curves are subdivided in two parts: an elastic part ranging from 0 to 225 µm and a plastic one ranging from 22 to 625 µm. These resistances decrease from the size 225 µm . Thus means that from this size 225 µm , the internal bond of these particleboards are no good.

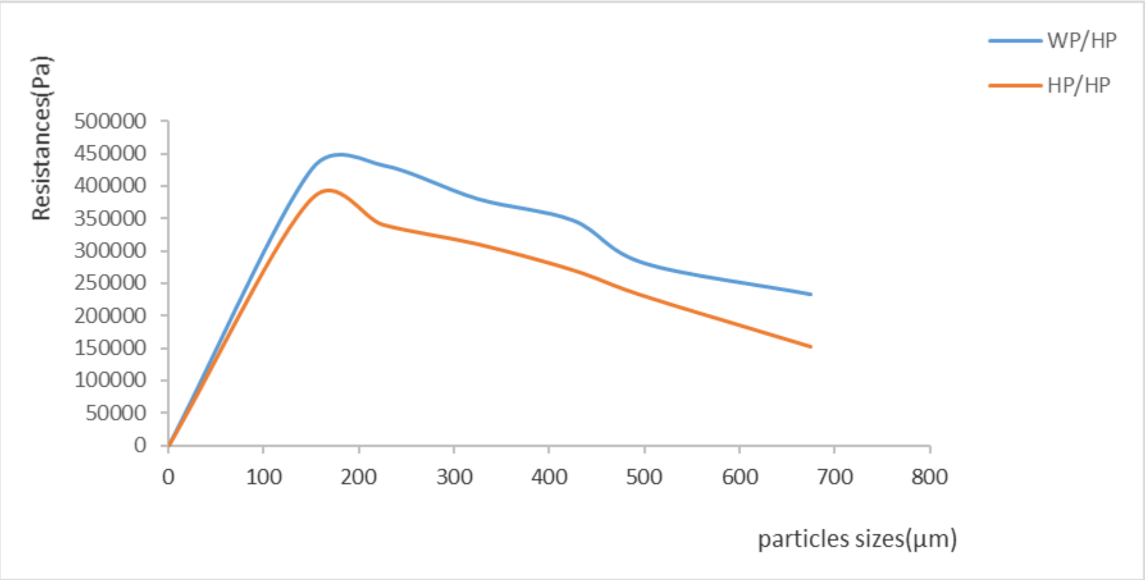

Figure 1: Variation of the resistance of particleboards WP/HP and HP/HP depending the sizes of particles.

The curves in Figure 2 below show the variation of MOE depending on the size of WP / HP and HP / HP particleboard. Two zones are observable on these curves, particular that ranging from 0 to 225 µm and those from 225 µm to 625 µm. In the first zone, the MOE values of WP /HP and HP/HP increase respectively in the interval [0 1850 MPa] and [0 1590 MPa]. Those of the second phase decrease respectively in the interval [1850 1362 Mpa] and [1590 950 Mpa]. The MOE means values of WP / HP and HP / HP are respectively 1571.33 MPa and 1322.66 MPa . the MOR and IB CURVES represented in figure 3 and 4 have the same behavior as those of MOE. While, The MOR maximum values of WP / HP and HP / HP are respectively 20, 2MPa and 13, MPa.

The Internal Bond average values of WP / HP and HP / HP are respectively. they can be used in an external domain because the values are greater than 0.35 MPa (NF EN 319,).

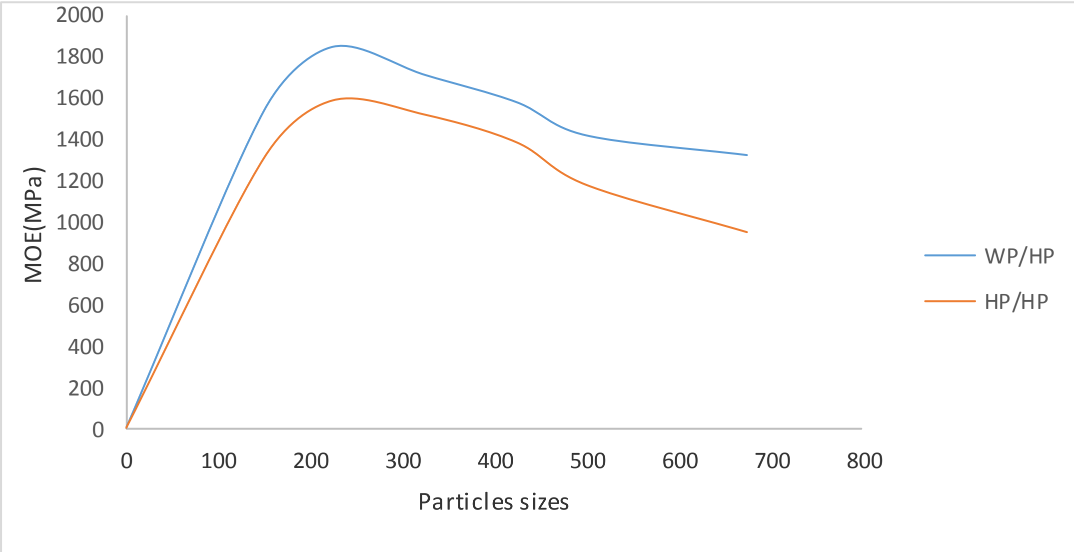

Figure 2 : Variation of MOE depending the particules sizes

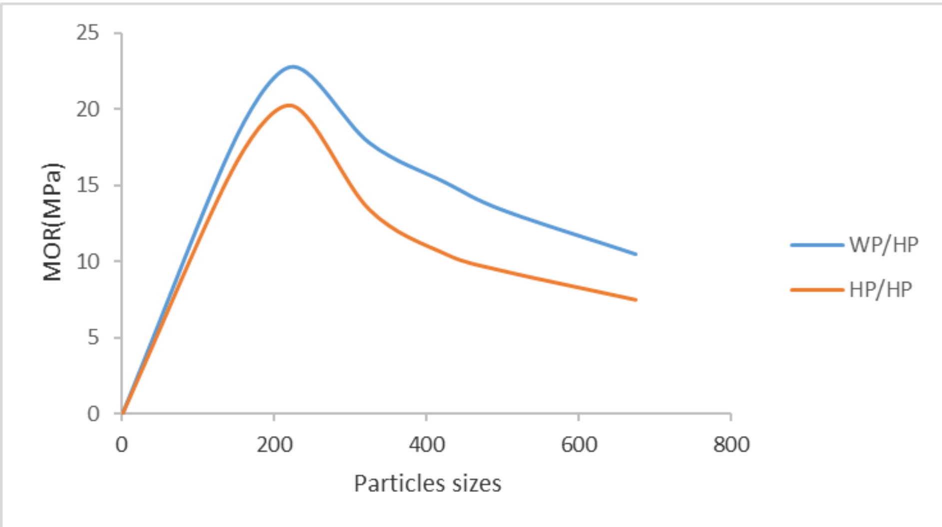

Figure 3: Variation of the modulus of rupture depending the particle size

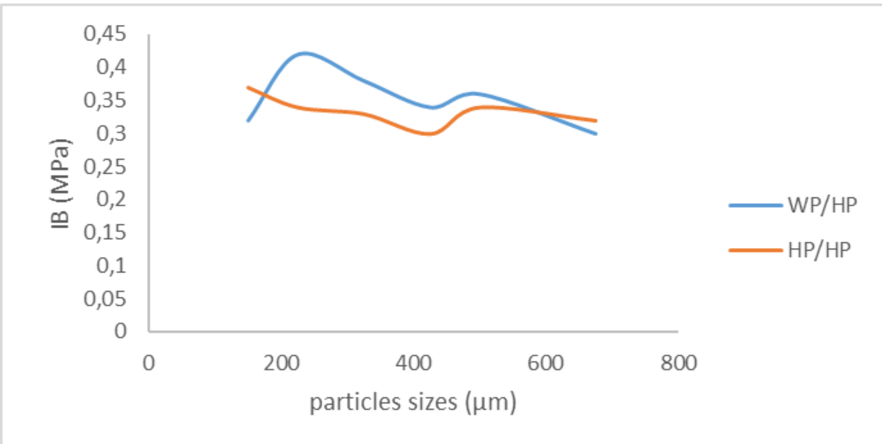

Figure 4: The variation of Internal Bond depending the particles size

3.2. **Physical properties**

The curves of figure 5 bellow describe the variation of apparent density depending the size of particles. The values of these two particleboards vary between 600kg/m3 and 800kg/m3. These values confirm that, the particleboards manufactured can be used in an external domain (ANSI A 208.1999).

The swelling rates during 2H and 24H vary between 40.7 to 65% and 44 to 72% respectively. The minimum values are 17 and 19% respectively. Concerning the water absorption rates during 2H and 24H, their values vary respectively between 45 to 80.2% and 86 to 110%. Their minimum values are 27.8 and 37% respectively. We note that the values of HP / HP are less than the WP / HP one.

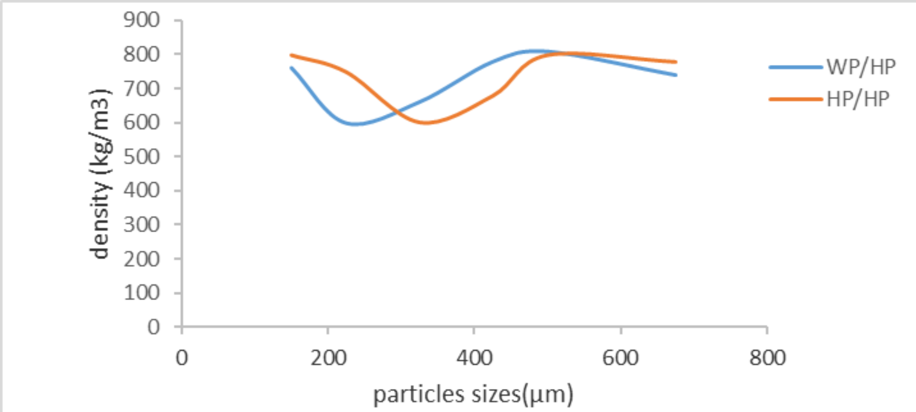

Figure 5: variation of the density according to the sizes of the particles

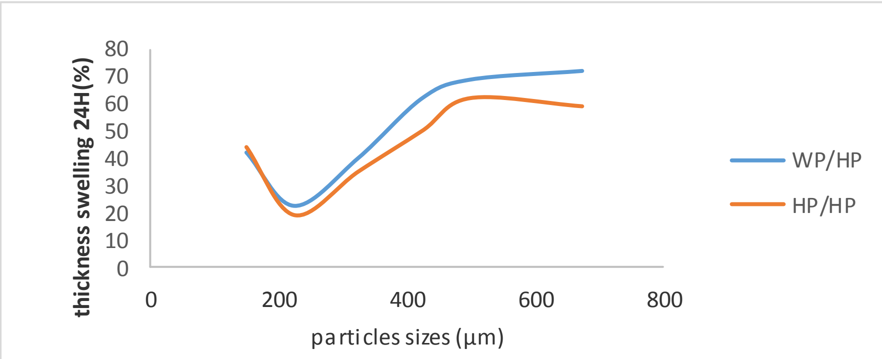

Figure 6: variation of thickness swelling according to the size of particles of horns during 24H

III. CONCLUSION

The resins developed with keratin horns are promising, the mechanical characteristics of the particleboards are interesting. The particleboards manufactured with these adhesives can be used in external domain.

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