MECHANIC AND PHYSICAL PROPERTIES OF PARTICLE BOARDPANELS PRODUCED WITH HORNS SHEATHS

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ABSTRACT

Two IP / HP and AP / HP bio composites, each made from a horn-clad powder resin and reinforced respectively with Iroko and Ayous wood particles, ranging in size from 125 to 625 µm were characterized. The best physical and mechanical properties were obtained at 225 µm. The values of thickness swelling ratio, density, modulus of elasticity, tensile strength modulus and internal cohesion of IP / HP and AP / HP at (225 µm) are respectively (21% for 2H and 22.4% for 24 hours, 600 kg / m3, 1850 MPa, 22.8 MPa and 0.52 MPa) and (17% for 2H and 19% for 24 hours, 750 kg / m3, 200N, 1590 MPa, 20.2 MPa and 0.44 MPa). It is deduced from these values that IP / HP and AP / HP are resistant but IP / HP is more resistant than AP / HP and can be used in a dry environment. The developed resin can be used in the wood industry.

Keywords: Bio-composites, keratin, particle board, horn cases, horn particles.

INTRODUCTION

Cameroon is an agro-pastoral country with more than 6.2 million heads of cattle, contributing 165 billion CFA francs and directly providing 30% of income to rural populations (MINEPIA, 2009). 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 (UNIDO 2000, SIARC, 2012) have been realized. Nowadays, farmers use horns as fertilizer to fertilize the soil, fattening fruit trees (AGRIDOC, 1997) 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 (BWLi et al, 2009), 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 (Luca Tombolato and al, 2009). Horn anisotropy is confirmed as well as energy dissipation (Jiyu Sun and al, 2016), keratin extracted from oxen hooves and a biocompatible material to promote cell attachment and has high thermal stability (Kakkar and 2014) as well as behavior by numerical analysis and image correlation (ZANG Dong-SHENG et al, 2006). 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 (AMADOU et al, 2004).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 ..., (Kumar et al, 2014); the epoxy used as brake pad and clutch disc (Kumar et al, 2016) 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 (nenonene, 2009) and tannin extracted from the reinforced woodchips aningre (Noel KONAI, 2015) 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 (IARC, 1995) allows us to find alternative solutions, that of completely eliminating these synthetic products. The work done using silk-cotton tree sawdust particles with the tanned powder of the pod (SoviwadanDrovou, 2015) 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.

MATERIALS AND METHODS

Preparation of raw materials

The ox horns are collected at the Maroua slaughterhouse and washed with water and caustic soda to clean the fat. They are then reduced to powder after drying at room temperature for 15 days. This powder is sieved at different mesh sizes, ranging from 150 μm to 625 μm and then packaged in the oven at 105 ° C. for dehydration.The figure 1Bellow shows the collection and transformation of oxhornes.

(a)

(b)

Figure 1: In form of hornes : a- bunch of oxhornes, b-grainthornready to beused

Preparation of adhesives

To obtain the horny resin, 300 g of horn powder are mixed in 1% of Na 2 S, 1% of pure NaOH and 98% of distilled water, then this mixture is introduced into a cooking flask and refluxed at reflux. 60 ° C for 3 hours, thereby obtaining an adhesive ready for use.

PH measurement of the solution

It consists of placing the solution to be analyzed under magnetic stirrer (after calibration of the pH meter), the probe must be well positioned in the solution in order to avoid any shock then wait for the stabilization of the chronometer pH meter to deduce the pH.

Particleboards preparation

Two particle boards manufactured with the adhesive described above were studied, namely WP / HP and HP / HP. They were made using wood particles from carpentry waste of two species Iroko and Ayous as reinforcement.In fact, the manufacture of these particle boards (size 350 mm x 300 mm x 13 mm) consists in mixing the sample of each particle with 10% of the adhesive developed above using a mixer for about 3 minutes. The mixture of each sample was compacted in a three-phase press, namely 32 kg / cm 2, 15 kg / cm 2 and 5 kg / cm 2 for 5 min, 5 min and 3 min, respectively, at 180 ° C. Each sample Particle board was cut for physical and mechanical testing.

Mechanical properties

The 120 mm x 20 mm x 12 mm samples were cut in accordance with EN 326-1. The three-point bending tests were carried out using a JFC-H5KT brand dedicated apparatus, with digital data acquisition at a speed of 3 mm / min. Before each mechanical test, the samples were conditioned in a condenser for 24 hours at 20 ° C.

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

The modulus of elasticity and the flexural strengths are determined according to standard NF-EN 310. The values of MOE and MOR retained correspond to the average of 10 samples in each case.

$$MOE = \frac{L^3}{4xbxe^3} x \frac{F_2 - F_1}{a_2 - a_1} \quad (1)$$

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

Where F_i the measured force (N) for a displacement a_i(mm);
F_r the load measured at break (N);
L distance between the points of support (mm);
b width of the specimen (mm);
e thickness of the test piece (mm).

Internal Bond

Internal Bond (IB) of each particle board were made on 10 test pieces of dimensions 50 mm × 50 mm × 12 subjected to traction perpendicular to the surfaces according to standard NF EN 319.

$$\mathrm{IB} = \frac{\mathrm{F_m}}{\mathrm{S}} \quad (3)$$

Where F_m maximum breaking force (N);
S solicited area (mm2).

Physical properties

Thickness Swelling and Water absorption

The thickness swelling ratio (TS) and the water absorption rate (TA) are determined according to standard NF-EN 317 on 10 test specimens of dimensions 50mm × 50mm × 12mm. The thicknesses and masses are initially measured using a Vernier caliper and a scale, then each sample is immersed in water for 2 and 24 hours. After removing each sample in water, they are dehydrated and placed in a refrigerant for 60 minutes.

$$TS = \frac{e_f - e_i}{e_i} x100 \quad (4)$$

Where $e_i$thickness of the specimen before immersion (mm);
$e_f$thickness of the specimen after immersion (mm).

$$\text{TA} = \frac{m_f - m_i}{m_i} x100 \quad (5)$$

Wherem_i initial mass of the specimen before quenching (g);
m_f final mass of the test piece after quenching (g).

1.2.2 Apparent volumetric mass

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

$$\rho = \frac{M}{V} \quad (6)$$

Where ρ density of the test specimen (kg / m3);
M mass of the test piece (kg);
V volume of the specimen (m3).

RESULTS AND DISCUSSIONS

Preparation of raw materials

The dry matter of the cowhide sheaths is 96%, after drying the particles in an oven, the average dry matter obtained is 92%. These results show that the moisture content in the horn is low, this is an advantage during the shaping of the composite. This low humidity improves the mechanical characteristics of the composite (Augier, 2007).

Preparation of the resin and measurement of the pH of the solution

The oxhide-based particle resin was produced without the addition of volatile gas or toxic product, it is 100% biodegradable, and the pH of the solution was adjusted to 12, this could reduce the freezing time of the solution (N.konai, 2016).

Mechanical properties

The table below summarizes the maximum values of the forces and resistances as well as the elongation of the panels IP / HP and AP / HP obtained the tests of three point bending.

Table 1 : maximal value of the resistance force and elongationpanelsIP/HPand AP/HP

Particules of panels	Maximal resistance (N/mm^2)	Elongation(%)	Maximal force (N)
IP/HP	450	3.2	397
AP/HP	210	2.2	254

From these results, it is deducedthat the maximum values of IP / HP and AP / HP are respectively 450 N and 210 N. Therefore, IP / HP is more resistant than AP / HP, this could

be justified by the modules. ofelasticities of wood particles used as reinforcement. The longitudinal elasticity moduli of the wood used are 12840 MPa for Iroko and 7260 MPa for Ayous, respectively (J.P.Jauneau, 2008). The elastic modulus of elasticity of Iroko is much higher than that of the ayous of a difference of 5580 MPa. The elongations are respectively 3.2% for Iroko and 2.2% for ayous, this means that AP / HP breaks faster than IP / HP.
The curves in figure 1 ;figure 2 and figure 3bellow shows the variation of MOE the variation of MOR and the variation of IB in function of the height and particule of the panel IP/HP and AP/HP. Two zones are observable on these curves, in particular that ranging from 150 to 225 microns and those ranging from 225 to 625 microns. In the first zone, MOE values of IP / HP and AP / HP increase respectively in the range [1541, 1850 MPa] and [1311, 1590 MPa]. Those of the second phase decrease respectively in the interval [1850, 1324 Mpa] and [1590, 950 Mpa]. The average MOE values of IP / HP and AP / HP are 1571.33 MPa and 1322.66 MPa, respectively. The curves MOR and IB shown in FIGS. 3 and 4 have the same behavior as those of the MOE. While, the maximum values of MOR of IP / HP and AP / HP are respectively 22.8 MPa and 20.2 MPa, those of the internal cohesion are respectively 0.52 MPa and 0.44 MPa. They can be used in a dry environment because the values are higher than 0,35MPa (NF-EN 319). These values are similar to the work on the characterization of particle board based on acacia tannin resin (ELBADAWI et al, 2015). The wrong values are found in the size 625 µm for all the mechanical characteristics.

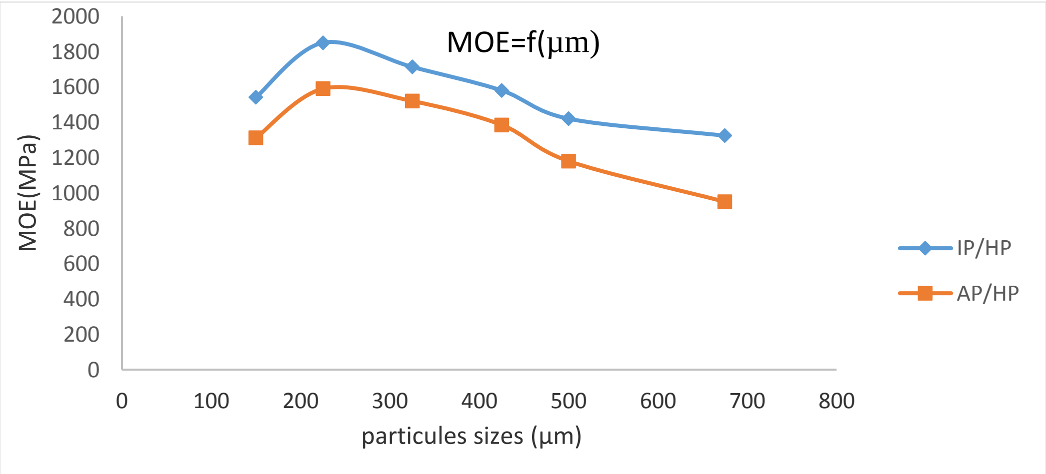

Figure 2:MOE variation with particle sizes of cattle horn sheaths

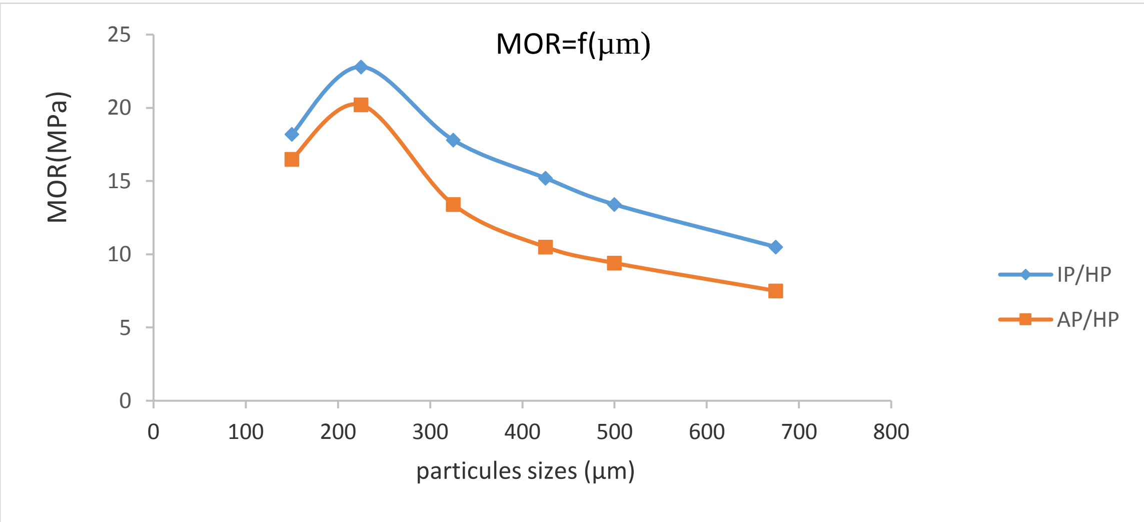

Figure 3:MOR variation with particle sizes of cattle horn sheaths

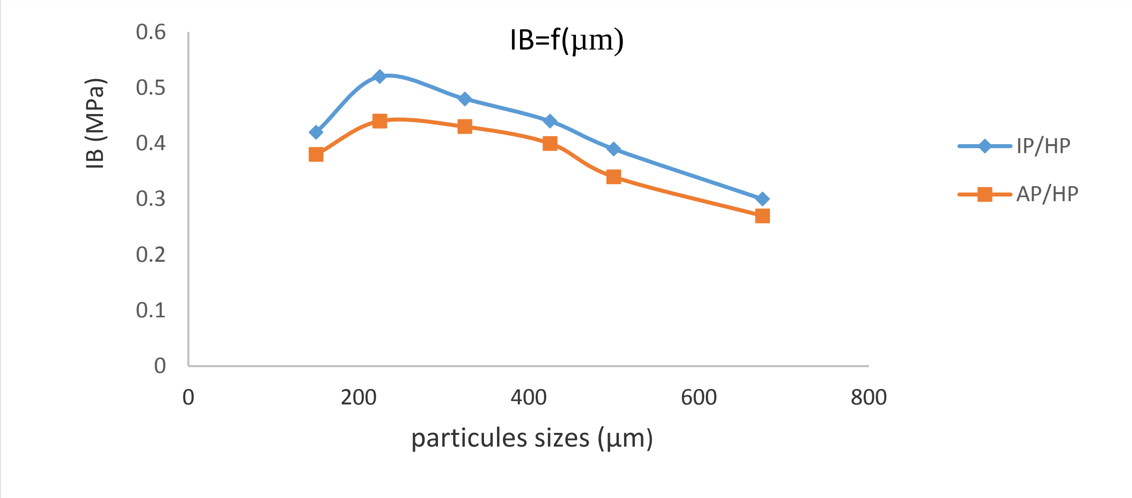

Figure 4:Variation of internal bond according to particle sizes of cattle horn sheaths

Physical properties

The curves in Figure 5 below describe the change in bulk density as a function of particle size. The values of these two particle boards vary between 600 kg / m3 and 800 kg / m3. These values of fabricated particleboard can be used in a dry environment (ANSI A 208.1999) and are similar to work with melamine formaldehyde resin (Natasa et al, 2011). The swelling rates in thickness for 2H and 24H vary between 40.7 and 65% and 44 to 72% respectively. The minimum values are 17 and 19% respectively. Regarding the water absorption rates for 2H and 24H, their values vary respectively between 45 and 80.2% and between 86 and 110%. Their minimum values are respectively 27.8 and 37%. We note that HP / HP panel values are lower than those of WP / HP panels, indicating that they can withstand moisture in a WP / HP environment and are similar to panels made from Tannin Resin*Austranelacongolensis* (konai, 2016).

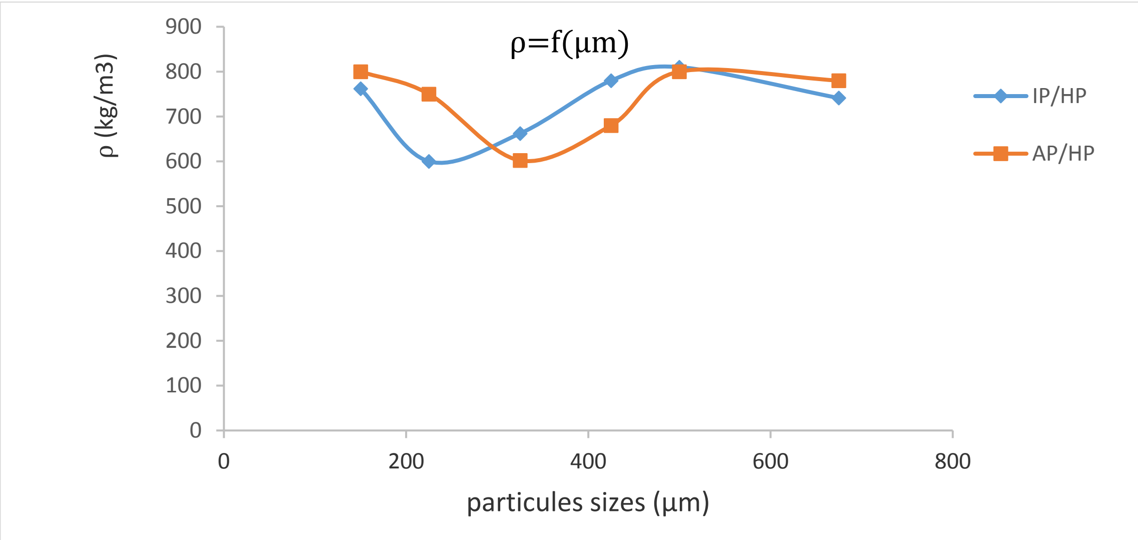

Figure 5:Variation of densities as a function of particle sizes of cattle horn sheaths

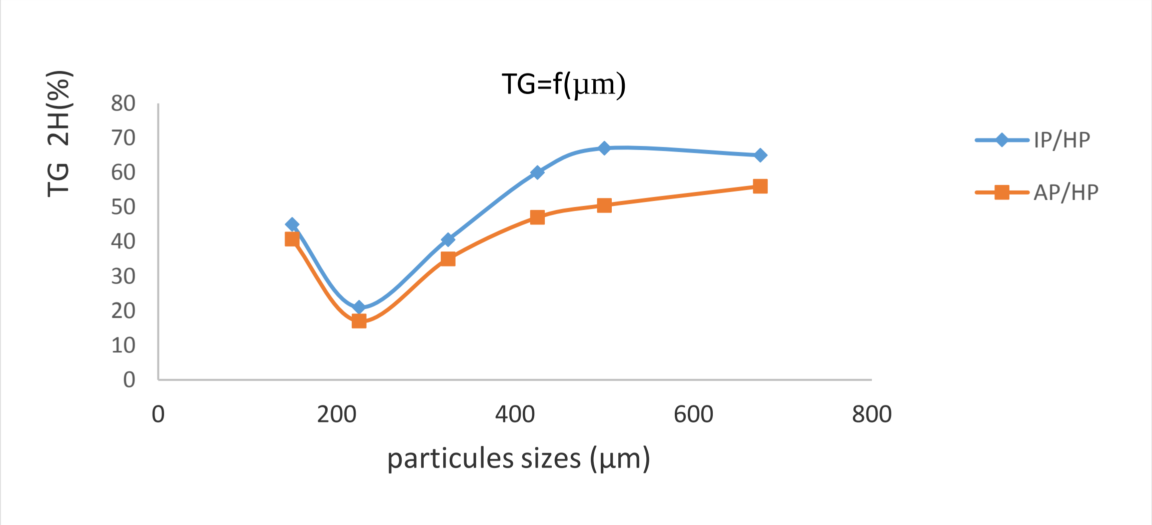

Figure 6:Variation in thickness swelling rates versus particle sizes of cattle horn sheaths during 2H and immersion in water

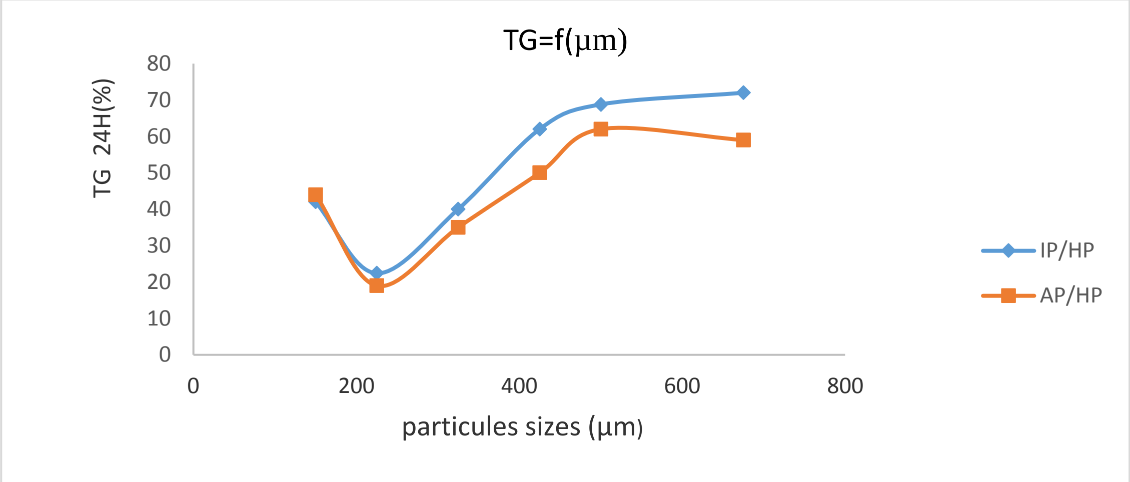

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Figure 7:Variation in thickness swelling rates as a function of particle sizes of cowhide sheaths during 24 hours of immersion in water.

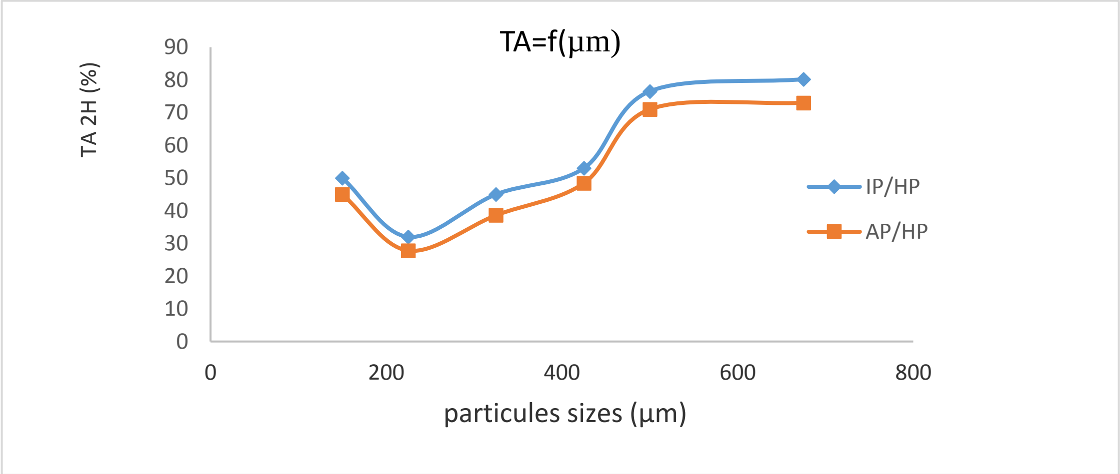

Figure 8:Variation in water absorption rates according to particle sizes of cattle horn sheaths during 2 hours immersion in water.

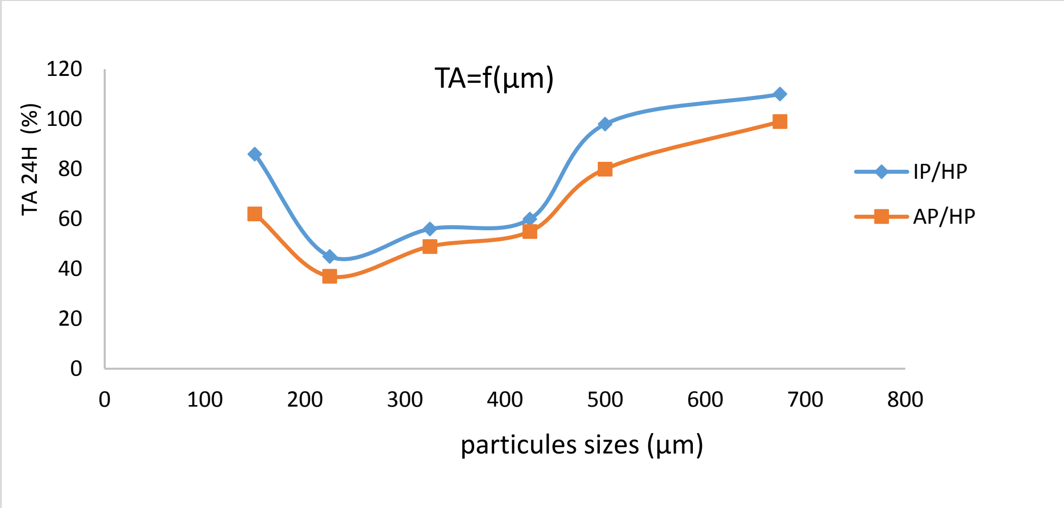

Figure 9:Variation of water absorption rates according to particle sizes of cattle horn sheaths during 24 hours of immersion in water.

CONCLUSION

Horned keratin is a molecule compatible with wood particles because it has a very good polymerization during thermo pressing particle board. The resin developed with the ox horn shells is promising in view of the physical and mechanical characteristics obtained which are well above the recommendations of the ANSI A 208.1999 standard for chipboard reinforced with woodchips. They can be classified in the middle grade of particle board and used in a dry environment. Other types of vegetable fillers can be studied for the reinforcement of this biodegradable resin.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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