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Evaluation of Physical Properties and Acoustic Performance the Agglomerates of Wood Pellets Polyurethane Residue

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Abstract: One of the biggest problems faced nowadays is the incorrect disposition of residues in the environment; creating a big volume of material. In order to reduce the quantity of material thrown in the environment and, at the same time, provide an alternative of reusing it, combined with a possibility of reducing the noise issued in constructions, the polyurethane residue agglomerates were made with wood particles. The objective of the present study was to evaluate the performance of agglomerates fabricated with different proportions of wood's particles of Eucalyptus Grandis Hill ex Maiden and polyurethane granular solids from footwear sector of Três Coroas/RS city, using as binding agent Elastan 8004/Br, a pre-polymer. The proportion of polyurethane granular solids and wood particles used were 0/100, 15/85, 30/70, 45/55 e 60/40% (m/m). The performance of agglomerates was evaluated by water absorption and thickness swelling at 24 hours and acoustic performance in relation to airborne noise. Polyurethane addition caused reducing the values of water absorption and thickness swelling. The acoustic performance of materials showed that the agglomerates with 40/60% of PU has the highest reductions in sound level and, consequently, the better sound insulation.

Key words: agglomerates, polyurethane granular solids, wood particles, acoustic performance

1. Introduction

New clusters that bring both environmental and economic benefits are being developed by industry to be used in different sectors. The wood pellets are produced in panels with wood particles with the incorporation of a synthetic adhesive and consolidated by applying pressure [1]. According to J. Li, X. Luo, X. Lin [2], applications of clusters are indicated for the packaging industry, and also used in civil construction. The production of pellets with the usage of waste from different sources can contribute and stimulate the production of new materials as the use of lignocellulosic residues and polymers that contribute to soften environmental impacts in the footwear industry, PU is used in shoe soles for their lightness and comfort, resistance to abrasion, tearing and bending, as well as its elasticity and flexibility [3]. In order to minimize the problem of polymeric materials disposal, the incorporation of polyurethane (PU) waste is a viable alternative for the development of agglomerates**.** The society of now-a-days is day by day more demanding about the situations of confort on the buldings. Among them, stand out the situations of thermal confort and acoustic. The noise inside the buildings is one of the mains causes of complaint by the inhabitants, and there attenuation demand for locks with better acoustic performance [4]. The clusters can be use in floors and lightweight structures, working as estructural element of small to average postage in applications of residencials building [5]. The objective of this study is to evaluate the influence of different levels of PU residue in wood pellets in agglomerates with the analysis of the moisture content and acoustic performance.

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2. Experimental

Waste of footwear made of rigid PU were donated by the Syndicate of Industry of Footwear of Três Coroas/RS. Prepolymer with the base of polyester's resin saturated and diphenylmethane of diisocyanate (MDI), was donated by BASF polyurethanes Ltda. Was provided by BASF polyurethanes Ltda (Brazil), mold release Spray of silicone Jimo® and the boards of wood of *Eucalyptus grandis W. Hill ex Maiden* were give in by the State's Foundation of Agriculture's Research — FEPAGRO FLORESTAS, Santa Maria/RS.

The wood's particles were processed in a mill of knives MARCONI® model MA580. The particle's selections were made in sieves of the serie Tyler of 9, 14, 20 and 28 Mesh Tyler by a mechanical's agitator PRODUTEST®, for 10 minutes. The wood's particles used in the making's clusters were of 9, 14 e 20 Mesh Tyler (Fig. 1a). The rigid PU waste was milled in a granulator's mill horizontal vibratory PRODUTEST® of 6 and 20 Mesh Tyler, by standard NBR 7217:1987. Were selected particles of 20 Mesh Tyler in the clusters's making (Fig. 1b). The wood's particles (PM), the PU's waste, the Elastan 8004/BR® and the water were mixed in a mortar's mixer electromechanical CONTENCO®, in a speed of 830 rpm (Fig. 1c).

Fig. 1 (a) Wood Particles, (b) PU Solid Granules and (c) Mixture PU with Pre-Polymer and Water

Were prepared five different proportions between wood's particles and PU's waste (Table 1).

The mix was transferred for a wood's box (32×32×10 cm) coated with film of polyethylene of low density. The mix contained in the wood's box was pressed in a system of manual press, in the environment's temperature, in 2.7 kgf cm^{-2} of pressure, by a period of 24 hours. After the pressing, the clusters were removed and put in camera. Were made three clusters in each treatment, totaling 15 clusters, with dimensions of 32×32×1.4 cm and specific's bulk nominal of 0.35 g cm^{-3} (Fig. 2).

The clusters of determination of the water's absorption and swelling in thickness of the clusters were made second standard NBR 14810-3: 2002 after immersion in water for 24 hours. Were used samples

Table 1 Proportions of PU's Waste and Woods Particles for Making the Clusters

Samples	Materials	
	Polyurethane waste (% m/m)	Wood's waste (% m/m)
1	**0**	100
2	**15**	85
3	**30**	70
4	**45**	55
5	**60**	40

Fig. 2 Agglomerate of Wood Pellets with Polyurethane Residue

with 5.0×5.0×1.4 cm of width and the measures were made with a universal caliper rule and the bulks of the samples were determined in an analytical balance of the mark OHAUS. The resistance of the impact IZOD was determined according the rule ASTMD 256 [8], in a machine CEAST® equipped with hammer of 1 joule, in 25ºC, applying a speed of impact of 3.46 m/s.

The test for determinate the isolation acoustic airborne noise was made in camera reverberant in a scale reduced and as the procedure of the standard ISO 140-3 [9], with two positions of sound source in the source room, three positions of microphone in the reception room and measurement in bands of third octave. The sounds sources placed at the corner of the source room have frequency answer of 90 Hz to 20,000 Hz. The equipments used in these measurements were an amplifier of power 2716 Bruel & Kjaer and a sound analyzer 2270 Bruel & Kjaer. The samples were placed between two plates of plaster gypsum, as intended for this material as fill lightweight partitions (Fig. 3).

3. Results and Discussion

Clusters of wood's particles go through high alterations when exposed to humidity. The effects of humidity in the clusters cause significant alterations in its properties may precluding its uses in some external environments or with purposes structural [10]. The

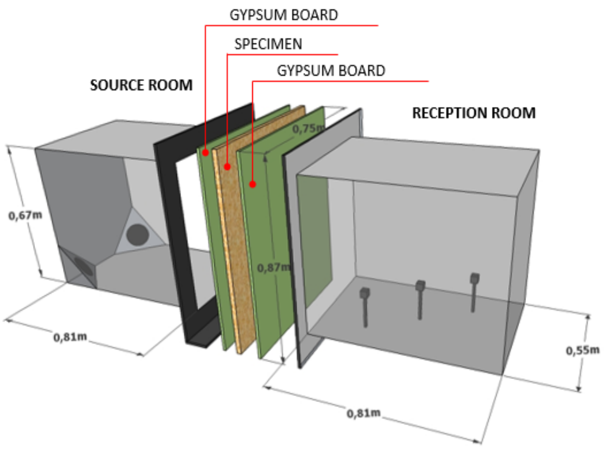

Fig. 3 Scale Model Rooms for Airborne Sound Measurements, Position of the Acoustics Equipment in the Source and Reception Rooms and the Sample Between Two Gypsum Board

mean values of the water's absorption, after 24 hours of immersion (Table 2), vary of 64.04% for the clusters compounds exclusively by wood (average in D), to 27.29% for the compounds of 60% of PU's waste and 40% of wood.

The higher rate of water's absorption was verified in the clusters compound exclusively of wood, verifying a gradual decrease in the absorption as the measure that increases the content of PU's waste. That fact can be assigned to the character hydrophobic of the PU [11] and to the increase of the places available for the water's penetration when its reases the wood's content in the composition of the clusters [12].

After 24 hours of immersion in water, the average's values of swelling in thickness (Table 3) vary of 6.10% for the clusters compounds exclusively by wood, to 2.52% for the clusters compounds of 60% of PU and 40% of wood. The result obtained corroborates thoses of Paes (2011), who says that the swelling in thickness of clusters is directly related to the water's amount absorbed by them [13]. The higher stability dimensional verified on the clusters made with the higher PU's content indicates the advantage on the use of these clusters in situations that the humidity can be a factor limiting to the using of the wood's panels.

Table 2 Water's Absorption of the Clusters after 24 Hours of Immersion

Materials		Absorption 24 hours
PU (% m/m)	Wood (% m/m)	(%)
0	100	65.04±2.68
15	85	54.27±1.04
30	70	54.27±1.04
45	55	49.08±1.04
60	40	27.29±1.04

Table 3 Swelling 24 Hours

Material		Swelling 24 hours (%)
PU (% m/m)	Wood (% m/m)	
0	100	6.10±0.18
15	85	4.75±0.19
30	70	4.71±0.18
45	55	2.74±0.19
60	40	2.52±0.18

Beyond of the contribution of the PU's waste for increases the stability dimensional of the panels, the agent binder made of MDI has an important contribution in its resistance to the humidity. Like Bucur (2006), one of the mains functions of the adhesive is prevent the water's absorption by diffusion, avoiding the decrease of the dimensional stability of the clusters [14].

According Shmulsky and Jones (2011), resins made of MDI are proofed of water, being applied, mainly, in the made of wood's clusters resistant to the humidity (PACKHAM, 2005) [15]. Compared to the rule of commercialization EN 312 (2003) [16], that recommends a maximum value of swelling of 14% for the panel's clusters with 13 to 20 mm of thickness, all of the values obtained in the present's job were satisfactory, framing up inside of the limits established by them.

The samples' set analyzed submitted less isolation acoustic in the averages frequencies, between 125 Hz and 1000 Hz. The differences of the level between the samples feature three different behaviors. Until 125 Hz the panels with 15% and 30% of PU feature higher values that the others. On the mean frequencies the samples with 60% of PU has a difference of sound level higher and, on the frequencies starting on 1000 Hz, no of the samples stands out.

The Fig. 3 has a comparative between the system of partitions without filler material and the system of partitions compound by the different panel's clusters.

The Average Moisture Content (AMC) of particle boards ranged from 9.78% for panels exclusively made of wood, to 4.30% for panels with 40/60 wood-PU, the addition of waste PU yielded a decrease in the AMC of the clusters. The cluster 40/60 of PU residue showed better performance compared to the reduction in sound level, showing the biggest reductions in frequency bands of 125, 250, 500, 2,000, 4,000, 8,000 and 16,000 Hz.

4. Conclusion

The acoustic performance of materials showed that the agglomerates with 40/60% of PU has the highest reductions in sound level and, consequently, the better sound insulation. Agglomerated with wood particles and PU granular solids can be used in the sound insulation on partitions, walls, coating and ceilings, with applications in conditions where the humidity is limiting factor for the usage of 100% wood. The use of such material can qualify the acoustic comfort of environments, without the environmental consequences related to the use of materials traditionally employed for filling acoustic partitions.

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