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# Manufacture of particleboard based on cement bag and castor oil polyurethane resin

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## HIGHLIGHTS

- Discarded cement packaging recycling.
- Production of particulate panels from cement packaging with three densities (0.4; 0.5 and 0.6 g cm$^{-3}$).
- Physical and mechanical properties of the cement bag-based panels.
- Particulate panels with 0.6 g cm$^{-3}$ density meet physical–mechanical performance requirements recommended by ANSI (1999).

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## ABSTRACT

This study assesses the potential of cement packaging residues from building site wastes to produce particle boards. Panels with 0.4, 0.5 and 0.6 g cm$^{-3}$ and 15% of castor resin content were produced and its chemical, physical, mechanical and microstructural were analyzed. The results revealed that the packages have a high cement content and low lignin pulp. Furthermore, the increase in density reduced the physical properties while enhanced mechanical properties, being the 0.6 g cm$^{-3}$ particleboards the only formulation with potential to produce particulates. Thus, the packaging of cement becomes an option for the manufacture of particle board.



## 1. Introduction

The panels are composed of particles of cellulosic material (usually wood), produced by the fragmentation of pieces or particles bonded with an adhesive [1]. These panels are used in the production of furniture, cabinets, cabinetry, stair treads, house building, shelves, vanities, tabletops, sliding doors, pool tables, schools and other applications in industrial products [2].

However, the reduction of forest reserves and the imminent desertification in many tropical countries have directed researchers to find other lignocellulosic biomass as an alternative raw material for production of these panels [3,4].

An alternative is to study the use of agro-industrial wastes for the manufacture of particle boards, since the chemical composition of this biomass is similar to the timber, more precisely hardwoods containing low lignin content and higher hemicellulose content of pentosans type [5].

Information from the literature indicates that more than 30 plants were evaluated as an alternative raw material for the production of particulate panels [6]. Some of the plants studied as an alternative raw material for the production of particulates were: Sunflower stalks [6], Hazelnut husk [7], Peanut Hull [4], Sugar cane bagasse [8], Coconut fiber [9] Walnut shell [10], Almond shell [11] and Kenaf [12], Rice husk [13], Coffe husk [14], Sugar cane bagasse [15], Coconut fiber [9] and Peanut Shell and Coconut fiber [16].

However, besides the problem of agricultural waste, other solid waste that has drawn attention is the incorrect disposal of cement packaging after use in civil works. In 2011 world production of cement was 3638 million tonnes with an average consumption of 513 kg/inhab [17].

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These packages are made of kraft paper, which consist of fibers derived from wood pulp (Pinus sp). When discarded by construction, are burned or dumped into the environment, resulting in contamination of soil, air and groundwater. Therefore, their recycling is an alternative solution to this problem [18].

By the fact that it is derived from wood, Kraft paper used for packaging of cement can be an alternative feedstock for the production of particulate panels, and these have the advantage of being sustainable, helping to mitigate the environmental impact of this waste and at the same time helping solve the problem of forest reserves.

The literature does not provide information on the use of cement packaging for the production of particle board. In this context, the aim of this study is to investigate the feasibility of using cement packaging discarded by the civil works for the production of particle boards bonded with polyurethane resin based on castor oil.

## 2. Material and methods

### 2.1. Particle production

The cement packaging from civil works were collected and taken to a container with 120 L of water for solid waste removal from packaging, since these residues negatively influence the wear of equipment and the adhesion process with the resin particles of the panels. For each wash a ratio of 15 bags of cement was used.

After washing, the bags were randomly and manually chopped in order to generate small particles. Subsequently, the particles were moved to a vertical pulper machine MRF 31450 model with 190 L of water. The hydroxyl groups present in the chemical structures of the fibers (cellulose and hemicellulose) are connected through hydrogen bonds with water molecules, thus promoting the transfer of mechanical energy from the mixer to the fibers disaggregation.

The particles were kept in the pulper machine for a period of 12 h to ensure that the entire mass of the packaging transformed into pulp (Fig. 1a–c). Then, using a sieve (0.150 mm) was removed excess water adhered to the pulp and directed to a centrifuge (C2A05BBANA) for 3 min.

After centrifugation, the pulp was put into a planetary mixer (MT120) during 5 min in order to disaggregate the particles adhered to the pulp. Then, the particles were placed in a circulating air oven (MA035), at 60 °C until a moisture content of 8% (Fig. 1d), since the use of particles (Pinus sp.) with up to 8.6% of humidity does not affect the mechanical properties of the panels with polyurethane resin based on castor oil [19].

After particles drying, these were transferred to a vibrating screen (Produtest) to classify the grain size. Particles that were retained in 8, 4 and 2 mm mesh were used to manufacture the panels.

### 2.2. Manufacture of the panels

The production process of the panels was initiated by loading the particles in a planetary mixer (MT120) for three minutes to homogenize the mixture of particles with bicomponent polyurethane resin based on castor oil (15% dry weight of the particles). After mixing, the material was placed into a mold to form the mattress with dimensions of 40 cm × 40 cm × 1 cm and further transferred to a thermo-hydraulic press, where 5 MPa pressure was applied, temperature of 100 °C, for 10 min (Fig. 2).

Subsequently, the produced panels were kept at 20 °C and 65% relative humidity for the complete cure of the material. Nine panels were produced, three for each density (0.4, 0.5 and 0.6 g $cm^{-3}$).

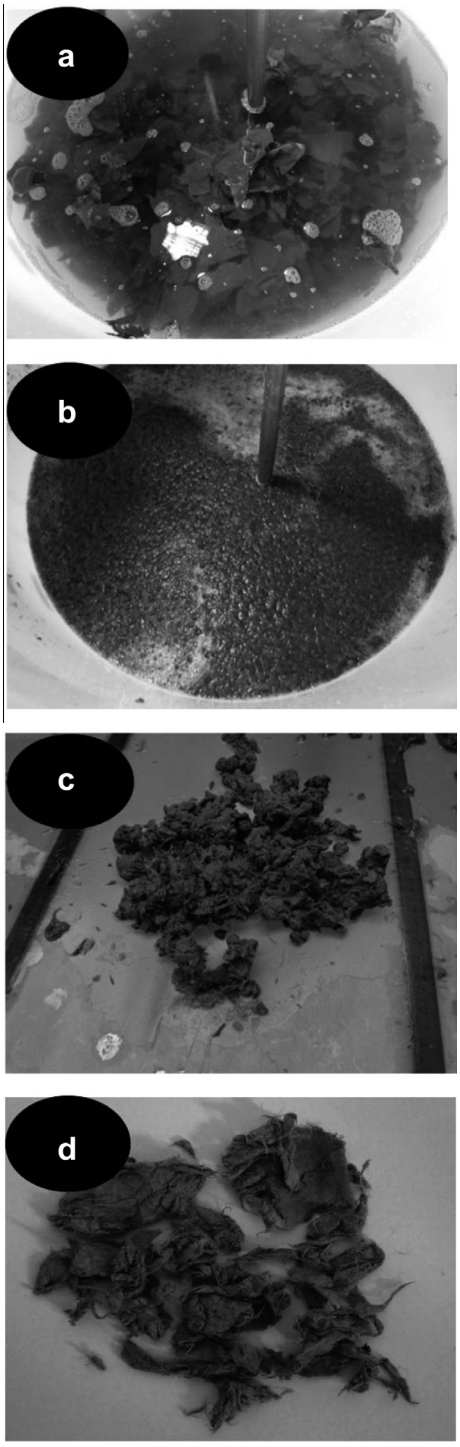


**Fig. 1.** Manufacturing process of packaging cement: (a) chopped paper; (b) pulp in water; (c) pulp without excess water; (d) particles with 8% moisture content.

### 2.3. Microstructural analysis

Microstructure and energy dispersive spectrum (EDS) analysis of the particles (before and after wash) and Scanning Electron Microscope (SEM) analysis of the particle boards (0.4, 0.5 and 0.6 g $cm^{-3}$), using a Hitachi Analytical Table Top Microscope TM300. EDS aimed to verify the existence of residual cement in the materials submitted to the washing process.