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Study of the implementation of waste wood, plastics and polystyrenes for various applications in the building industry

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HIGHLIGHTS

- A process for recycling waste wood, polystyrene and plastics is proposed.
- The process is based on optimal formulations of polymers and composites.
- The values of the properties studied show that the polymers are compatible with sawdust.
- Composites can be used to produce panels and wood boards.
- Wood boards and panels can be used for building wood structures.

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ABSTRACT

This work enrolls in the context of sustainable development and protection of the immediate environment. It concerns a recycling study of wood waste, polystyrene waste and plastic waste. The objective of this study is to upgrade wood waste and plastic wastes (low and high density polyethylene) and expanded polystyrene in waste disposal in the developing countries of Africa. Two types of wood particle composites based on plastic and polystyrene polymers have been developed. The physical properties (density, water absorption and volumetric swelling) and mechanical properties (modulus of elasticity and modulus of rupture) required for their implementation are determined. The quantities found show that these composites can be used to produce self-adhesive sandwich panels or boards which will serve as a door core, false ceilings, formwork sandwich boards, interior and exterior flooring and furnishing materials.

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1. Introduction

In Benin, the daily use of plastic materials has reached a worrying level (Table 1). Indeed, according to Dessau [1], Benin landfills have welcomed more than 12,000 tons of plastic waste, more than half of which consists of packaging bags, 86% of which are thrown into the street after use. 5.50% are burned, 5.50% is incinerated and the remaining 3% is used for other purposes. The general observation is that plastics are an integral part of Benin's everyday life. Several studies have shown that plastic bags, whose life span varies between 100 and 400 years depending on the conditions, have a significant influence on the living environment and their enormous and multiple consequences range from the environment to human health.

According to the Ministry of Animal Resources of Burkina Faso, about 30% of the mortality of livestock is attributed to the plastic bags following their ingestion by the animals. In Togo, it was found that high chickens and sheep die from stomach occlusion after confusing bits of plastic with worms of leaves and leaves [2].

In addition, plastic bags accumulate in the soil to form successive layers. So the soil becomes unstable and the result is landslides, as was the case in many Third World countries where deaths were reported. It should be noted, among other things, that plastic bags are also partly responsible for water scarcity. The explanation allows us to affirm that the drying out of wells and boreholes is also the consequence of poor management of the user plastics which, buried under the sand, prevent the water from infiltrating into the ground to reach the aquifers Causing flooding, with the clogging of runoff pipes. And in Cotonou (Benin), the economic

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Table 1
Quantity of different plastic waste in the cities of Benin.

N°	Plastic type	Tons of plastic waste in the cities of Benin					Percentage
		Cotonou	Porto-Novo	Parakou	Other cities	Total	
1	HDPE	2314.67	84.47	118.17	544.27	3061.58	36.30
2	LDPE	191.25	534.00	244.79	3440.85	4410.89	52.29
3	PP	32.09	28.16	–	181.42	241.67	2.87
4	PET	103.49	12.20	126.61	78.64	320.94	3.8
5	PVC	–	7.21	8.44	46.44	62.09	0.74
6	PS	–	18.93	16.88	121.98	157.79	1.87
7	PUR	81.87	12.01	8.44	77.44	179.72	2.13
8	Total	2723.37	696.98	523.34	4491.00	8434.69	100

Source: Etude Eco Plan-Tractebel [3].

capital, this situation increases the risks, due to the occupation of the natural passages of the water by the houses.

In Table 1, (HDPE) refers to: High Density Polyethylene, (LDPE): Low Density Polyethylene, (PP): Polypropylene, (PET): Polyethylene Terephthalate, (PVC): Polyvinyl Chloride, (PS): Polystyrene, (PUR): Polyurethane.

In addition, there are significant quantities of wood residues (Fig. 1, Table 2) resulting from the different uses of sawmills wood in Benin. These residues are either dumped in the wild or burnt, thus contributing to pollution of nature and increasing greenhouse gases. We must not lose sight of also the expanded polystyrenes of packing which become bulky after unpacking the goods household appliances and motorcycles.

Municipalities and companies involved in the management of developing countries are currently seeking ecological ways and means to exploit non-biodegradable waste because they can only dispose of it by burial and incineration. This practice has a negative impact on the ambient air and soil.

It is in order to change this practice, that we propose in this work an approach to transform plastic waste, expanded polystyrene and sawdust collected in composite materials for use in wooden structures.

Composites are solid materials obtained by combining reinforcement and/or without a filler and a matrix of complementary characteristics. These two materials are linked together by a contact zone which constitutes the interface. The quality of the interface affects the mechanical properties of composites [5,6]. The reinforcement forms the skeleton, or else the framework of the composite. Its function is to bear the bulk of the mechanical stress applied to the composite material, whereas the matrix ensures the bonding of the reinforcements to each other, their protection of the external environment and the distribution of the mechanical load

Fig. 1. Sawdust dump at the Saclo/Bohicon wood processing plant in Benin (West Africa).

Table 2
Quantity of timber and sawdust produced in Benin (West Africa) in 2013, 2014 and 2015.

Year	Volume of timber (m^3)	Quantity of sawdust (tone)
2013	8517.200	2981.02
2014	13260.300	4641.10
2015	13033.500	4561.72

Source: DGFRN/ONAB [4].

within the material [6,7]. The combinations giving rise to the best properties (rigidity, mechanical strength, lightness, corrosion resistance, etc.) are the ones that attract attention. Clyne and Hull mentioned in their work [8] that composites can also be classified according to the nature of their matrix, into five main families. Ceramic matrix composites (CMC), metal matrix composites (MMC), intermetallic matrix composites, carbon-carbon composites (CCC), polymer matrix composites (PMC). The reinforcements used in general are fibers such as glass, carbon or aramid fibers and natural fibers.

The present work relates to polymer matrix composites with reinforcements such as wood particles. Wood particles, unlike wood fibers, have no privileged dimensions. According to EN 309 [9], lignocellulosic particle boards are a combination of lignocellulosic materials and an adhesive matrix in which the components retain their integrity. The matrix may be constituted by natural resins, artificial resins. Maloney [10] mentioned that their development is carried out in a process whereby any gap between the particles is filled by the binder; others can be added during manufacture to improve certain characteristics of the panel. It has also subdivided particleboard into two main categories according to the pressing method. We distinguish:

- Panels pressed flat when the pressure is exerted perpendicularly to the faces as in conventional multi-plate heating presses;
- Extruded panels when the direction of application of the pressure is parallel to the faces.

Generally, the particle board is produced in four main stages:

1. The fractionation which is the phase of preparation of the woody material into particles of a certain granulation;
2. Impregnation consists of mixing the fibrous material with the binder material. It is carried out by spraying the resin into a colloidal suspension in water, in a mixer of the solid. The distribution of the resin is a determining factor for the quality of the panels. When the matrix is thermoplastic, the mixture can be made by incorporating the fibers into the melt-compounding polymer;