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# An experimental investigation on morphological, mechanical and thermal properties of date palm particles reinforced polyurethane composites as new ecological insulating materials in building

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ABSTRACT

The rigid polyurethane (PU) with apparent density about 40 kg/m$^3$ was prepared using commercial polyols and polyisocyanate. This reference petrochemical formulation was modified with natural and renewable components such as date palm particles (DPP). The goal of this investigation was to reduce the environmental impacts, and reduce the cost of the petroleum based polyurethane (PU) by obtaining polyurethane/date palm particles (PU-DPP) composites with the heat insulating and mechanical properties similar or better as in the case of the reference material (PU). The composites were prepared with different (DPP) loading; 5%, 10%, and 20% (by weight). The results showed that heat insulating and mechanical properties of the (PU-DPP) composites were comparable with those from reference petrochemical formulation (PU). On the other hand these mechanical and thermal performances are competitive with those of other insulating material available on the market. Hence the (PU-DPP) is a good candidate for development of efficient, low cost, and safe insulating materials.

## 1. Introduction

The polyurethane (PU) foams are one of the most widely used plastic materials in the world [1], they represent a wide range of commercial products commonly classified as flexible, semi-rigid and rigid foams depending on the starting ingredients [1–3], common polyurethane applications include; building insulation, freezers and refrigerators, furniture and bedding, automotive [3].

One of the most important applications of polyurethane in building is insulation [3], indeed, the insulation plays a fundamental role in reducing energy consumption and also it creates a healthy and comfortable living space. In winter, the insulation keeps the heat in and thus limiting the building's heat loss. In summer, it also limits the flow heat between the outside and inside the building [4]. Today there are commercially many insulators and often the choice is not always obvious. Yet each insulator is characterized by a set of specific physical properties which allow both comparing them and identifying their most appropriate application [5].

PUs are formed by chemical reaction between a hydroxyl terminated polyether or polyester and isocyanate in the presence of catalyst and other additives, forming repeating urethane groups [6,7], PU foams have several advantages of lightweight, low cost, and especially good adherence with other types of materials such as wood. More importantly, they are popular insulating materials with excellent insulating properties for their lowest thermal conductivity over other cellular materials. Hence, PU foams take up a considerable fraction of PU production [8,9]. However, PU foams are known to have negative impacts on the environment during

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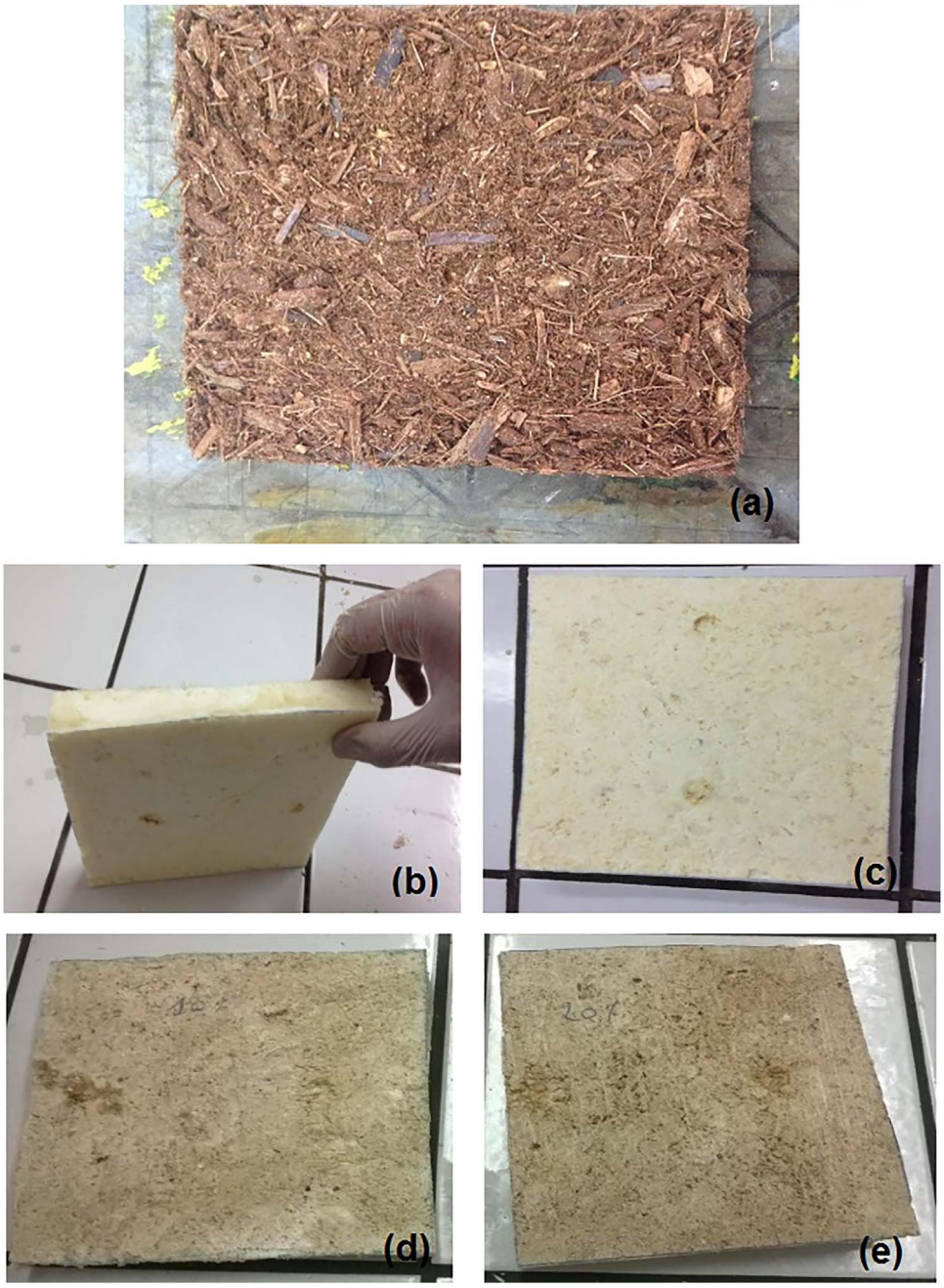


**Fig. 1.** DPW and PU-DPP composites preparation: (a) DPW (b) PU (c) PUR-DPP5 (d) PU-DPP10 and (e) PU-DPP20.

their whole life cycle, and raise serious health concerns in case of fire for example. Moreover, they present a high contribution to global warming potential. All these factors have put a spotlight to replace these polyols from bio-renewable resources [10].

The effect of wood fibers or particles reinforcement in various type of matrix such as polypropylene and polyurethane has been widely studied, Georgieva et al. [11] demonstrated that the amount of fiber had significant effects on foam qualities, indeed, as more fiber was introduced the tensile strength decreased, in contrary, compressive strength of the PU spray foam was found to be superior with high fiber content, Gu et al. [12] concluded that the amount of wood fibers have negative effect on foam qualities, indeed as more as the fibers were introduced the foam had inferior tensile strengths, meanwhile the fiber reinforced PU spray had better thermal stability following the increase of fiber loading. Fornasieri et al. [13] synthesized and characterized polyurethane composites of wood waste and polyols from chemically recycled pet, it had been reported that the adhesion between the two phases was occurred by formation of covalent bonds. Gu et al. [14] studied the feasibility of polyurethane composite foam with added hardwood pulp; the obtained results showed that the introduction of wood pulp fibers in PU foam insulation did not significantly alter its mechanical