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Study of Wood-Plastic Composites with reused High Density Polyethylene and Wood Sawdust

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Abstract

In recent years, concerns about environmental preservation have motivated industries to adapt towards more environmentally friendly materials, resorting for this to recycled and waste materials. This has been the center for a growing number of research studies to enable less and less virgin materials waste [1], [2]. The use of recycled thermoplastics has been considered for the production of wood and plastic composites in recent years [3]. New materials have been developed with a view to developing eco-composites, materials with several advantages, both at an environmental level and an ecological level, including natural polymers[4]. Solid plastic waste from polymers such as high density polyethylene is creating new challenges for an industry that is seeking greater waste utilization to ensure products that are efficient ecologically and environmentally friendly [5][6]. The cost and quality of these composites depends on the waste type incorporated, on the material and the processing route used [4]. The sawdust waste produced by the sawdust industry is about 5% per tree log, which makes this an important renewable raw material [2]. The objective of this study was to investigate composite material properties developed from reused HDPE thermoplastic material from the thermoplastics injection industry and pine sawdust from the lumber industry. The materials were developed with three different volume fractions of pine sawdust and two different particle sizes, mixed in a double screw extruder. A validation of a processing route – injection molding – was also performed.

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Keywords: Materials; Sawdust; HDPE; Recycled.

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1. Introduction

Technology has contributed to a major development of mankind, but many times at the expense of the environment and natural resources. Toxic, non-degradable materials were, for many years, the basis on which this development was carried out. Increasing awareness for sustainability issues led governments and companies to derive towards using ecologically appropriate materials. To reduce, reuse and recycle have been increasingly applied principles in practice, when dealing with materials, processing and product design and development. Incorporating recycled materials back into the product lifecycle enables a visible reduction in virgin raw materials usage, thus lowering the impact on natural resources[7], [8].

Composite materials, being defined as the combination of two different types of materials, have high potential for contributing for this reduction in virgin materials usage. This is because they can consist on a combination of materials, that otherwise would be wasted, into a single, different material, which can be used in a new application. Classic composite mechanics has already addressed the main issues of the matrix / reinforcement system, and how the type, size and distribution of reinforcements affect the composite material properties. Traditionally, particle-reinforced composites are manufactured towards cost optimization of parts, whereas fibre and especially continuous fibre composites are designed towards increased mechanical performance. In this work, the incorporation of natural particles - sawdust - into a synthetic matrix - high density polyethylene - is studied. The composite material that emerges is called a Wood-Plastic Composite, or WPC. The base materials were chosen because they both are waste materials from local industries. This means that the re usage of these materials may have an impact on local economy [9]–[11].

The study focused on obtaining mixtures of high-density polyethylene (HDPE) and sawdust having different particle sizes and several mass percentages. These materials were then characterized mechanically, after being processed by injection moulding.

2. Composite Materials

Nowadays, materials are usually classified into five main groups: metals, ceramics, polymers, semiconductors and composites [8]. Composite materials are composed of 2 or more materials: a matrix material that transmits the mechanical stresses; and a reinforcement material that supports the stresses in the composite. The major evolution of this type of materials occurred in the second half of the twentieth century. In the 1980s and 1990s its use became common in space vehicles and military aircraft because they were materials with better performance than the materials used until then. Concerns about the environment and reduction of manufacturing costs led to a reintegration of the use of natural fibres in reinforced composite technologies [10], [12], [13].

The Wood-Plastic Composite sector has been a steadily growing within the plastics industry. WPCs are usually obtained from wood waste such as bamboo, pine, straw, and other cellulose based fibres, mixed with synthetic plastics such as polyethylene, polypropylene and polyvinyl chloride. Coupling agents, lubricants and stabilizers are usually added to enable good adhesion and processability to these composites [11], [14], [15].

High-density polyethylene has been used since the 1950's. Nowadays, it remains as one of the most used thermoplastics. It has a good impact resistance, as well as a good chemical resistance. It can achieve crystallinity levels up to 90%, meaning increased mechanical properties. It is also easily processed by extrusion, blow moulding and injection moulding [16].

Wood is a very important natural resource, especially in Portugal. Woodworking is a strong industry, and has been evolving successfully towards incorporating new designs and technologies into their products. Pine wood (*Pinus Pinaster*) is one of the main wood types used in Portugal, and hence one of the main sources of wood residues (sawdust)[17].

3. Experimental procedure

The flowchart on Fig. 1 shows the general procedure undertaken to develop and characterize the composite materials. Pine sawdust was dried and controlled for granulometry prior to the mixing stage. Then, HDPE is added