Chapter

# Introductory Chapter: The Importance of Composites in the World

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The title of this book is composed by three well-known keywords. The first, **composites**, refer to something that is made up of several parts or elements, an overarching thematic. In fact, almost everything in the world is a composite, from the grain of sand to buildings or even the living beings. **Renewable** is a word that contains a fantastic concept, which we all aspire to: Anything renewable can be replaced or has an infinite source. When renewal is made in a timely manner, we can say that it is sustainable. This book provides ways and solutions for the creation and/or use of composites produced by **sustainable materials**.

Composites are currently used in a wide range of activity sectors, ranging from consumer electronics to the aeronautics and space industries. The excellent mechanical properties and low specific weight form the basis of the increasing volume of structural applications. An important milestone in the large-scale use of composite materials was the Airbus A380, the largest commercial aircraft in the world. Despite the progress achieved, there are significant obstacles to the generalization of structural applications of composites, not only in terms of high material costs but also due to the complexity of the mechanical behaviour. In fact, there is currently no sufficiently deep knowledge of the mechanisms of damage and ruin, especially with regard to composites made from renewable and sustainable materials.

Natural fibers are increasingly associated with attempts to replace other fibres and also with improvements in reinforcing structures [1]. For example, the incorporation of coconut fibres into a composite material of polyethylene and cork dust has already been studied, and an increase in tensile strength compared to unreinforced material has been found [2]. In another study, different laminates of fibreglass, hemp, flax and basalt were compared in flexural tests. The best performance was achieved by hybrid laminates in comparison with those made of only one type of fibers [3].

Today there are many studies in the field of composite materials with the goal to make the world greener. For instance, in the building sector, Dweib et al. [4] developed an all-natural composite structure for housing roof application. The materials used were resin based on soybean oil and natural fibers such as flax, cellulose, recycled paper and chicken feathers. These composite structures were compared with the wood structures currently used in construction and were completely able to effectively meet the requirements. These examples demonstrate the capability of sustainable composite materials as well as the breadth of exploitable applications.

Research teams across the globe are focusing on biocomposites, e.g. fiber-reinforced composites with both reinforcement and matrix from natural and renewable resources and also on hybrid solutions, consisting of natural fibers and oil-derived matrix or vice versa. Currently, hybrid solutions are more successful than fully green ones, usually due to cost, durability, performance and/or restrictions specific to the application. Nevertheless, fully green composites are gaining momentum in

several industries, e.g., sustainable biocarbon fillers derived from wastes (biomass, industrial, food, etc.) have been showing a tremendous potential for the manufacturing of lightweight composite parts for the automotive industry [5].

From the perspective of mechanical engineering, the main values of a composite are its high strength coupled with its low specific weight, which allow it to be used in mobility applications, such as those related to transport. However, with the advent of nanotechnologies, enhancement additives such as nanomaterials and biodegradable ones, and technologies for composite manufacturing, have enabled new applications in the opposite spectrum of mechanical strength, for example, with new filtration products.

Additionally, in the context of mechanical engineering, another challenge is the smart integration of processing and manufacturing technologies to successfully join renewable materials into green biocomposite structures that can compete with current solutions in both performance and cost. Currently, compatibility of these materials in composite structures is a major challenge, with many researchers focusing on improving the interface/bonding between these materials and, thus, the mechanical performance of these structures.

Water scarcity and possible treatment and/or purification processes for the elimination of heavy metals or pathogens are current issues. In fact, climate change aggravates this reality. Today there are biocompatible and non-toxic composites formed of natural matrices to which nanoparticles are added, forming a biodegradable composite film which is expected to be low cost and an effective way to remove pathogens from water.

Circular economy is a hot ideal on the agenda of many organizations and governments, which is worth to strive for zero waste and total recyclability. The use of highly efficient composites with renewable, recyclable or degradable reinforcements contributes to reduce pollution, reducing waste and promoting green economy. Reusability is clearly a mandatory solution for sustainability. The use of nanoscale additives can make a huge contribution to the customization (specialization) of the composite and, for example, to its degradation for reuse of constituents.

Reutilization of wastes currently disposed by several industries must be assessed in order to determine the possibility of creating new by-products, which will have a positive impact in the entire value chain. An excellent example is agglomerated cork, a by-product from raw cork usually used only for wine stoppers and/or premium products. Additionally, the growth in the utilization and impact of composites from renewable and sustainable sources do not solely depend on industry stakeholders, and governmental policies play an important role on the fostering of eco-friendly composites, which should positively impact both society and economy.

In a society facing dramatic problems related to pollution and excessive consumption of fossil fuel-derived products with low levels of recyclability, the authors tried with this book to collect recent contributions that aim to answer some of these major issues.

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