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Review

Green composites: A review of material attributes and complementary applications

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ABSTRACT

Despite the large number of recent reviews on green composites, limited investigation has taken place into the most appropriate applications for these materials. Green composites are regularly referred to as having potential uses in the automotive and construction sector, yet investigation of these applications reveals that they are often an inappropriate match for the unique material attributes of green composites. This review provides guidelines for engineers and designers on the appropriate application of green composites. A concise summary of the major material attributes of green composites is provided; accompanied by graphical comparisons of their relative properties. From these considerations, a series of complementary application properties are defined: these include applications that have a short life-span and involve limited exposure to moisture. The review concludes that green composites have potential for use in a number of applications, but as with all design, one must carefully match the material to the application.

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1. Introduction

As global societies continue to grow, increasing emphasis is being placed on ensuring the sustainability of our material systems. Topics such as greenhouse gas emissions, embodied energy, toxicity and resource depletion are being considered increasingly by material producers. Some of this practice is being driven by regulations (particularly in Europe as a result of legislation such as the end of life vehicle directive [1]), but increasingly, anecdotal evidence would suggest consumers are also demanding improved environmental credentials from the products they consume. Improving the sustainability of our material systems will require not just the development of new sustainable materials, but also the increased application of existing green materials.

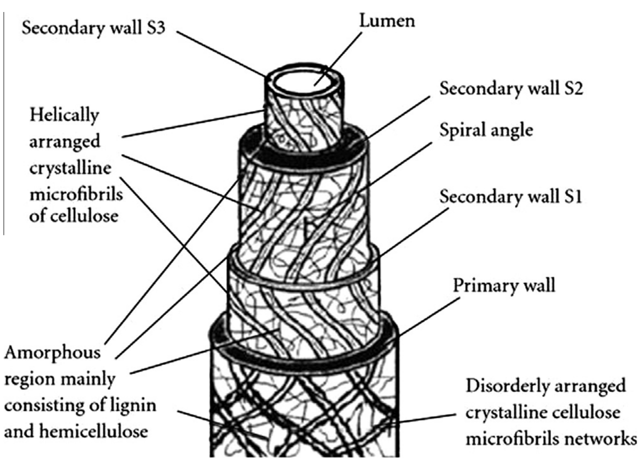

Fig. 1. Structural constitution and arrangement of a natural vegetable fibre cell [9].

One existing class of materials with good environmental credentials are green composites. Green composites are defined, in this work, as biopolymers (bio-derived polymers) reinforced with natural fibres. More specifically, this work will only look at the subset of green composites that are commonly considered as being biodegradable (counter intuitively, not all biopolymers are biodegradable), as defined by an appropriate standard (EN 13432 [2], EN 14995 [3]).

There are several recently published reviews on green composites, but unlike those, this work is not application specific, nor does it present the detailed chemistry of natural fibre and biopolymer enhancement. Instead, this work provides guidelines for engineers and designers on the appropriate application of green composites. For a detailed review of aspects relating to the materials science of green composites or their application in the automotive and construction sectors, the reader is referred to [4–8].

The initial part of this review provides a concise summary of the major material attributes of green composites. Significant results from literature are presented, as well as techniques and prospects

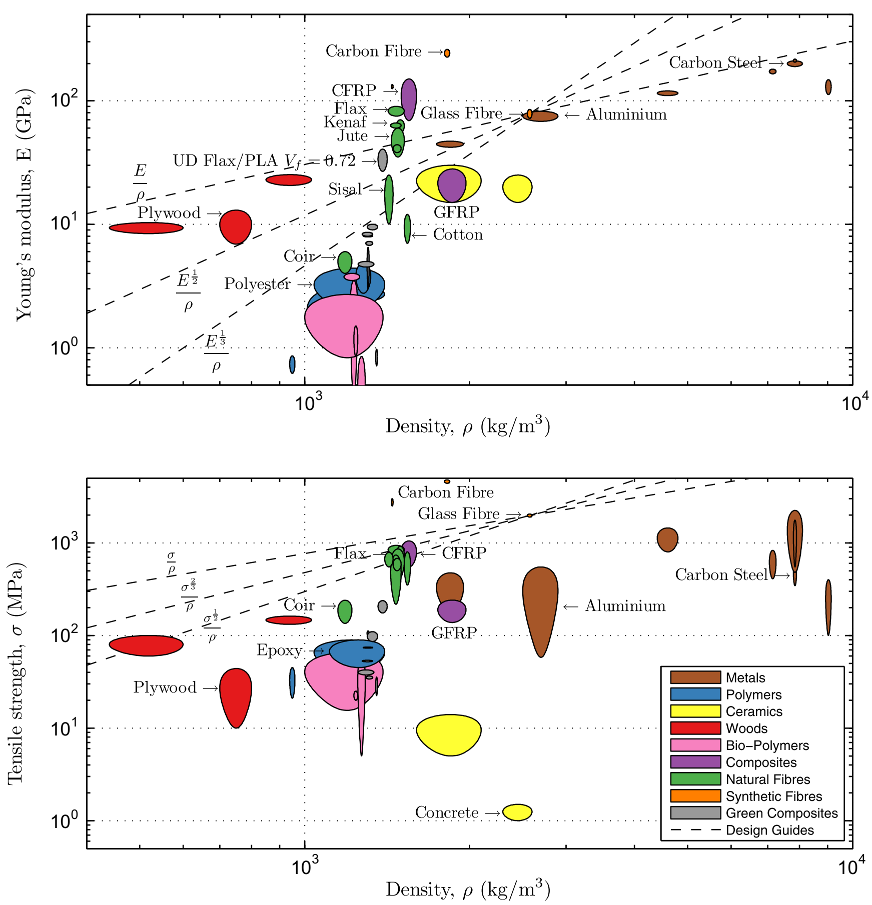

Fig. 2. Density specific mechanical properties. Dashed lines indicate constant material performance for tie stiffness E/ρ and strength σ/ρ, beam stiffness $E^{1/2}/\rho$ and strength $\sigma^{2/3}/\rho$ and plate stiffness $E^{1/3}/\rho$ and strength $\sigma^{1/2}/\rho$. Green composite properties from [76] (Long flax slivers/Randy PL-1000 PLA resin, 0.61–0.72 fibre volume fraction), [77] (10 mm length kenaf/PLA 3051D resin, 0.2–0.4 fibre weight fraction, only flexural strength and modulus reported), [78] (Woven jute fabric/soy resin, 0.4–0.6 fibre weight fraction), [79] (10 mm NaOH treated jute fibres/starch resin injection moulded, 0.1–0.3 fibre weight fraction), [80] (Abaca fibre pellets/PLA injection moulded, 0.3 fibre weight fraction), [81] (Jute fibre pellets/PLA injection moulded, 0.3 fibre weight fraction), [82] (Flax fibres/PLA and PHB resins, 0.3 fibre weight fraction, film stacking compression moulding), [83] (Flax fibres/PLA resin, 0.3 fibre weight fraction, film stacking compression moulding). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)