

PRO-DEGRADATIVE EFFECTS OF NATURAL FIBERS IN GREEN POLYMERIC COMPOSITES FOR 3D PRINTING



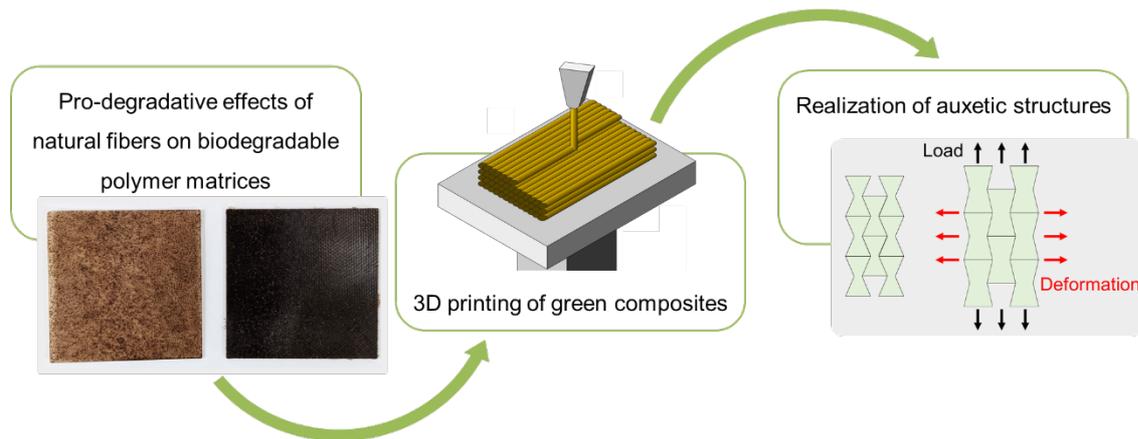
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Although the use and consumption of plastics have significantly improved human quality of life, their massive use is having a huge environmental impact and it is now urgent to switch to sustainable alternatives. Biobased polymers are increasingly attracting the attention of industry and academia as one of the ways of reducing the dependence on petroleum-based resources. These “green” plastics have the inherent advantage of being produced from renewable resources and, more important, they can be biodegradable or compostable. The latter point is highly desirable to reduce the environmental footprint. Many plastics are biodegradable, which means that they will break down into carbon dioxide, water, and a few other elements (mineralization), but the time needed to complete the process can be very long. The challenge is shortening this time as much as possible while preserving the excellent properties featuring plastics.

In the present study, this ambitious goal is pursued through a double approach: on one hand, the inherent pro-degradation ability of natural fibers is exploited; on the other hand, the potential of innovative manufacturing technologies is explored to maintain the mechanical strength. To reach these goals, biopolymeric matrices and vegetal fibers will be combined into green composites (objective 1), which will be manufactured to realize mechanically strong structures by 3d-printing techniques (objective 2).

Regarding the first objective, the fibers will act as a vehicle that triggers the degradation of the matrix. The shortened polymer chains can be hence mineralized by microorganisms. However, due to the presence of many hydroxyl groups in their chemical structure, natural fibers are strongly hydrophilic, while biopolymers are generally hydrophobic. This results in a very poor interfacial adhesion that promotes access from the external environment of water and microorganisms into the bulk of the polymeric matrix. To exploit the full potential of the pro-degradative effect of the fibers, the goal is to create three-dimensional networks of fibers throughout the composite. Therefore, attention will be paid to the content, size, and composition of the fibers. To study biodegradation, field and laboratory test will be performed. The former mimic environmental conditions experience in real applications; the latter are useful because of their short duration and the possibility of monitoring the progress of biodegradation. The poor interfacial adhesion promotes biodegradation, but it has a detrimental effect on the mechanical strength of the composite. The second objective of the present project consists of providing the materials with enough strength to meet the required performances. This goal will be pursued by designing auxetic structures. Due to a negative Poisson's ratio, such structures undergo lateral expansion when stretched longitudinally, and becomes thinner when compressed. This unusual mechanical response can be exploited to enhance the mechanical properties of green composites. Nevertheless, auxetic structures have complex geometries that are difficult to be manufactured. For this reason, innovative additive manufacturing technologies will be adopted. In particular, the auxetic structures will be realized by fused deposition modelling technique, which will require the production of green composites filaments with a constant diameter.



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