BIODEGRADABLE NANOCOMPOSITES FOR ACL REPLACEMENT MEDICAL DEVICE: A MECHANICAL STUDY

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Introduction

There is a growing research for synthetic solutions to anterior cruciate ligament (ACL) ruptures replacement [Laurencin, 2005]. Choosing appropriate materials for this application requires above all biocompatibility and mechanical functionality, which is a challenge. Currently, biodegradable polymers like polylactic acid (PLA) have been researched as a solution, allowing properly tissue regeneration and healing, being already approved by FDA. Despite that, PLA mechanical characteristics must be improved with mechanical reinforcements, namely its mechanical resistance to fatigue, preventing laxity or rupture of the device [Bernardino, 2010]. In an attempt to solve that it is presented an initial comparative mechanical study of some PLA reinforced composites.

Methods

For this study several nanocomposites were prepared with different and reduced weight percentages up to 2 wt%, into PLA matrix (Mw of 50000, Ingeo® 2003D, Natureworks LLC, EUA), namely graphene nanoplatelets (PLA/GNP – graphene nanoplatelets grade M5, 5 µm diameter and 6 and 8 nm thickness, XG Sciences, Lansing®, EUA), succinic anhydride functionalized graphene nanoplatelets (PLA/GNP-AS), oxidated graphene (PLA/GNP_{OX}) and succinic anhydride functionalized oxidated graphene (PLA/GNP_{OX}-AS). Also phosphate based glass P40 (PLA/PBG) [Parsons, 2010] composites were tested. PLA and remain specimens were prepared by melt blending, followed by compression moulding in a hot plates press, in 0.3 mm thickness thin films with a dog bone format for tensile tests. These were made in an Instron ElectroPuls E1000, with a load cell of 2kN, up to film rupture, under displacement control at a rate of 2 mm/min. It was used non-contact Feature Tracking Method [Xavier, 2009] for measurements.

Results

Some tensile tests results are presented in Table 1.

Specimen	Ultimate tensile strength (MPa)	Young's Modulus (GPa)	Possion's ratio
PLA	64.61±1.33	4.20±0.22	0.33±0.01
PLA/GNP0.5	58.21±2.37	4.20±0.15	0.32±0.02
PLA/GNP1	61.50±2.13	4.69±0.07	0.32±0.01
PLA/GNP2	58.32±4.16	4.92±0.15	0.32±0.01
PLA/GNP-AS0.5	49.41±5.36	3.88±0.09	0.33±0.02
PLA/GNP-AS1	30.21±5.86	4.61±0.18	0.31±0.01
PLA/GNP_{OX}1	48.25±15.13	4.18±0.11	0.32±0.02
PLA/GNP_{OX}-AS1	32.62±8.42	3.92±0.27	0.33±0.02
PLA/PBG0.5	54.44±7.27	3.63±0.58	0.31±0.06
PLA/PBG1	54.56±1.11	3.90±0.14	0.34±0.02
PLA/PBG2	43.47±1.16	3.72±0.20	0.36±0.04

Table 1: Results for PLA, PLA/PBG and PLA/GNP nanocomposites.

Discussion

Tensile tests showed a considerable increase in Young's modulus for PLA/GNP1 (99:1 wt%), PLA/GNP2 (98:2 wt%) and PLA/GNP-AS1 (99:1 wt%) nanocomposites, with an increase of 11%, 17% and 10% respectively, compared to PLA. Moreover, PLA/PBG did not cause elastic modulus significant changes, as well as PLA/GNP_{OX}. Nanocomposites preparation must be improved and more mechanical tests will follow this study, namely DMA, fatigue and creep/relaxation tests.

References

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