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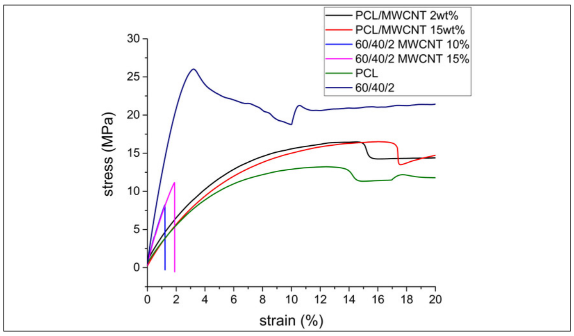
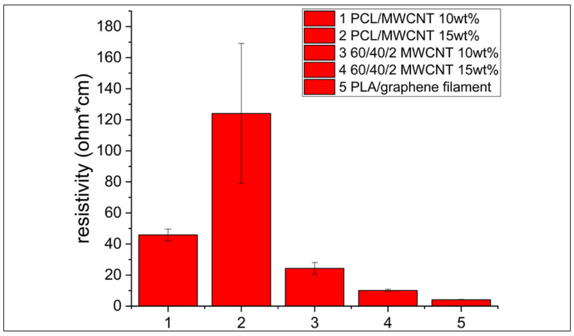
Subject Area	Innovation in Products, Processes and Materials - Industrial Technologies

Conductive Biodegradable Strings and Films for Activation of Electrocuring Adhesives



influence of MWCNT filler content on mechanical properties of neat PCL and PLA/PCL blend



electrical resistivity of processed composite strings measured with 4 point-probe measurement (with a current of 1 mA)

Introduction: To enable the application and activation of electrocuring diazirine grafted adhesives for medical purposes such as restoration of injured tissue, an electrically conductive, biodegradable substrate is needed. It is expected that the conductive pathway to electrocure the bioadhesive can be created by combining bio-resorbable polymers and conductive bioinert nanofillers. Research in development of such composites has been on-going, but current processing techniques are mostly limited to solution casting or in-situ polymerization. These processes require volatile organic compounds, are expensive and difficult to scale-up and automate. Polymer extrusion overcomes these hurdles, as it is solvent-free and offers possibilities of automation and continuous production. Therefore, the objective of this thesis is to extrude different composite strings and films and investigate the relationships between independent parameters such as processing parameters and matrix material and the resulting composite properties such as tensile stiffness and electrical conductivity.

Procedure / Result: Neat PCL and PLA/PCL blends with and without plasticizer (polyethylene glycol) are extruded into strings and films and characterized in terms of thermal, mechanical and electrical behavior. Untreated multiwalled carbon nanotubes are incorporated into different matrices in weight ratios of 2, 10 and 15 wt%. Electrical conductivity is evaluated using 4-point probe measurement. Adhesive curing is evaluated by dynamic mechanical electrorheology analysis.

PCL/MWCNT with filler content of 2wt% display resistivity in the range of 4-3000 MΩ.cm, which is not sufficient to electrocure the adhesives. PCL/MWCNT and PLA/PCL/MWCNT composites with filler contents of 8-15wt% meanwhile display electrical resistivity on the order of
10-130 Ω.cm, enabling the activation of the adhesives at an applied voltage of 10V. MWCNT contents of 2 and 8% in neat PCL matrix both lead to a similar increase in mechanical properties, enhancing the stiffness from 280 to 330 – 350 MPa. MWCNT contents of 10 and 15% in the PLA/PCL/PEG (60/40/2) matrix negatively affect the mechanical properties, with stiffness decreasing from 1230 to 740-760MPa and tensile strength from 26 to 9-10.5 MPa. The strain at break, being > 100% for the neat blend, decreases to 1.4-2.1% for the composites, characterizing its brittle behavior.

Solution: The results presented in this work demonstrate that extruded composite strings and films blended from bio-resorbable and bioinert components can display sufficient electrical conductivity to electrocure the bioadhesives. It was shown that by variation of matrix material and filler content, different electrical resistivity in the desired range can be achieved. With the equipment and materials used in this work, filler contents of a minimum of 8% were needed to achieve the conductivity which allowed an activation of the adhesives. The process presented in this report can be further optimized to lower the filler content while at the same time providing the resistivity needed for electrocuring.