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Synthesis and characterization of cellulose nanofibre for electrically conductive paper

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2017

https://hdl.handle.net/10539/24963

Ngobese, Sibonelo Sibusiso Justin (2017) Synthesis and characterization of cellulose nanofiber for electrically conductive paper, University of the Witwatersrand, Johannesburg, <http://hdl.handle.net/10539/24963>

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ABSTRACT

There is huge drive to identify sustainable, renewable, and environmentally friendly raw materials and right technologies to make or use them. These technologies should be applied in place of the conventional non-sustainable and non-environmentally friendly currently used materials. Nanotechnology involves the use of materials that have at least one side with dimension 10^{-9} m. There is considerable effort directed at the much abundant forest product such as cellulose which can be processed into cellulose nanofibrillated fibres (CNF) and cellulose nanocrystals (CNC). This study involved the synthesis and testing of an electrical conductive cellulose nanofibre made from microcrystalline eucalyptus grandis pulp. In this project, microcrystalline cellulose (MFC) from wood pulp was mechanically fibrillated using a Pilot Refiner to develop microfibrils. The microfibrilated pulp was oxidised with a mixture of 2,2,6,6-tetramethylpyradine-1-oxyl (TEMPO), sodium bromide (NaBr) and sodium hypochlorite (NaOCl) to produce CNF . The CNF was washed, sonicated and dried to produce translucent sheets. The oxidation process was able to achieve both CNF and CNC from wood pulp which was verified and characterized by Techpap, SEM, TEM, FTIR, Hounsfield Tensile Tester and Multimeter. The Techpap instrument indicated that the starting raw unfibrilated and mechanical fibrillated pulp fibre widths were 3.18 and 3.07 microns respectively. After oxidation process the FTIR Spectra produced an absorbance peak at approximately 1720 to 1740 cm^{-1} wavenumbers that is characteristic of the aldehyde carbonyl stretch which was not present on the unoxidised pulp. The average tensile strength of the paper strips were determined to be 4.51kN/m using the standard procedure of the experiment. From the TEM images it was observed that the CNF and CNC had dimensions ranging from 1.4nm to 594nm from pulp. The SEM images showed that on drying the CNF and CNC repolymerised into nanogel. The resistivity of the control CNF was in the infinity range. When the CNF was treated with the reduced Graphene Oxide (GO), the resistivity was determined to be 4400 Ω.m. This resistivity translates to an electrical conductivity of 2.27×10^{-4} $\Omega^{-1}.m^{-1}$ for a length of a paper strip that was 5mm long. The conductivity of the CNF material was significantly improved and fell within the range of semi-conductive materials. The overall research showed that the synthesized cellulose nanofibre hold a semi-conductor behavior, which add value information in the explored research area.