World Academy of Science, Engineering and Technology
International Journal of Materials and Textile Engineering
Vol:14, No:05, 2020

Characterization of Bio-Inspired Thermoelastoplastic Composites Filled with Modified Cellulose Fibers

Authors : S. Cichosz, A. Masek

Abstract : A new cellulose hybrid modification approach, which is undoubtedly a scientific novelty, is introduced. The study reports the properties of cellulose (Arbocel UFC100 – Ultra Fine Cellulose) and characterizes cellulose filled polymer composites based on an ethylene-norbornene copolymer (TOPAS Elastomer E-140). Moreover, the approach of physicochemical two-stage cellulose treatment is introduced: solvent exchange (to ethanol or hexane) and further chemical modification with maleic anhydride (MA). Furthermore, the impact of the drying process on cellulose properties was investigated. Suitable measurements were carried out to characterize cellulose fibers: spectroscopic investigation (Fourier Transform Infrared Spektrofotometer-FTIR, Near InfraRed spectroscopy-NIR), thermal analysis (Differential scanning calorimetry, Thermal gravimetric analysis) and Karl Fischer titration. It should be emphasized that for all UFC100 treatments carried out, a decrease in moisture content was evidenced. FT-IR reveals a drop in absorption band intensity at 3334 cm-1, the peak is associated with both –OH moieties and water. Similar results were obtained with Karl Fischer titration. Based on the results obtained, it may be claimed that the employment of ethanol contributes greatly to the lowering of cellulose water absorption ability (decrease of moisture content to approximately 1.65%). Additionally, regarding polymer composite properties, crucial data has been obtained from the mechanical and thermal analysis. The highest material performance was noted in the case of the composite sample that contained cellulose modified with MA after a solvent exchange with ethanol. This specimen exhibited sufficient tensile strength, which is almost the same as that of the neat polymer matrix – in the region of 40 MPa. Moreover, both the Payne effect and filler efficiency factor, calculated based on dynamic mechanical analysis (DMA), reveal the possibility of the filler having a reinforcing nature. What is also interesting is that, according to the Payne effect results, fibers dried before the further chemical modification are assumed to allow more regular filler structure development in the polymer matrix (Payne effect maximum at 1.60 MPa), compared with those not dried (Payne effect in the range 0.84-1.26 MPa). Furthermore, taking into consideration the data gathered from DSC and TGA, higher thermal stability is obtained in case of the materials filled with fibers that were dried before the carried out treatments (degradation activation energy in the region of 195 kJ/mol) in comparison with the polymer composite samples filled with unmodified cellulose (degradation activation energy of approximately 180 kJ/mol). To author's best knowledge this work results in the introduction of a novel, new filler hybrid treatment approach. Moreover, valuable data regarding the properties of composites filled with cellulose fibers of various moisture contents have been provided. It should be emphasized that plant fiber-based polymer bio-materials described in this research might contribute significantly to polymer waste minimization because they are more readily degraded.

Keywords : cellulose fibers, solvent exchange, moisture content, ethylene-norbornene copolymer
Conference Title : ICPCM 2020 : International Conference on Polymer Chemistry and Materials
Conference Location : Sydney, Australia
Conference Dates : May 18-19, 2020