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Extended Abstract

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MatSciEngg 2018: The effect of hydrolyzed cellulose pulp as a filler for LPDE, Jorge J. Coelho, CEMUC, Department of Chemical Engineering, University of Coimbra, Portugal.

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Abstract

The non-edible nature of cellulose, its abundance as available material in the form of wood or agriculture residues and its renewable character makes this natural polymer an interesting material to be used as environmental friendly reinforcement filler for conventional polymers [1]. The cellulose fibers due to their mechanical characteristics can improve the mechanical behavior of current polyolefins (e.g. PP, PE) if enough interaction between structures is provided [2]. Besides improving the polyolefins performance, depending on the degree of incorporation, cellulose fibers could also accelerate the biodegradation process of these materials.

Much of the works described the use of cellulose in the forms of microfibrillated [3] or nanocellulose [4], which are kinds of cellulose much more expensive than cellulose pulp used in paper production. Taking into account the possible industrialization of this type of reinforcement, it is important to get a much more available kind of cellulose starting as close as possible from native cellulose.

In this work, we hydrolyzed cellulose pulp using sulphuric acid method [5] to a powder form and prepared mixtures of this material with low density polyethylene (LDPE) in order to evaluate the effect on the mechanical properties. Homogeneous mixtures were achieved even with 30% of cellulose incorporation. The effect of amount of cellulose and the presence of commercial compatibilizers on the mechanical properties of the composites will be described.

Liquid crystalline nature of CNCs:

Under suitable conditions and at critical concentrations, all asymmetric rod-like or plate-like particles spontaneously form ordered structures, leading to the formation of a nematic phase. Rod-like CNCs, when dispersed in water, self-align to form chiral nematic phases with liquid crystalline properties. Their stiffness, aspect ratios, and the ability to align under certain conditions make them ideal for exhibiting liquid crystalline behavior. However, cellulose crystallites are known to have a helical twist down the long axis, similar to a screw, which can either lead to a chiral nematic or a cholesteric phase of stacked planes aligned along a perpendicular axis depending on the concentration.46 Various factors such as size, charge, shape, dispersity, electrolyte, and external stimuli can also affect the liquid crystallinity of CNC. The liquid crystallinity of nanocrystals coupled with the birefringent nature leads to interesting optical phenomena. The type of acid used for hydrolysis can also affect the liquid crystalline nature. CNC obtained by sulfuric acid hydrolysis often possesses a negatively charged surface, which promotes uniform dispersion in water due to electrostatic repulsions.50 Even though the interactions between nanocrystals are strong, highly sulfonated CNC is readily dispersible and this leads to the development of lyotropic behavior.51 Sulfuric acid- and phosphoric acid-derived CNCs normally give chiral nematic structure, whereas hydrochloric acid-derived CNCs with postreaction sulfonation give rise to a birefringent glassy phase.

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Mechanical properties:

The limitations in measuring the mechanical properties of nanomaterial's along multiple axes have made the quantitative evaluation of the tensile modulus and strength of CNC extremely challenging. In addition to this, different factors such as anisotropy, defects in the nanocrystals, percentage crystallinity, dimensions of the samples, and so on can also affect the results. Theoretical calculations and indirect experimental measurements using atomic force microscopy (AFM), X-ray diffraction analysis, inelastic X-ray scattering, Raman scattering, etc. were used to calculate the elastic properties of CNC.46 The theoretical tensile strength of CNCs was found to be in the range of GPa, which is much more than that of steel wire and KevlarIn another study, the elastic modulus of the CNC obtained from tunicates was determined using AFM, whereby the AFM tip was used to perform a three-point bending test. The elastic moduli of CNCs were found to be 150 GPa.47 Using AFM, the transverse elastic modulus of CNCs was also determined by comparing the experimental force–distance curves with three-dimensional finite elemental calculations.48 This measurement proved that the transverse modulus of an individual CNC lies in the range of 18–50 GPa. The deformation micromechanics analysis of tunicate cellulose whiskers using Raman spectroscopy proved that the calculated modulus of tunicate CNC.

Conclusion :

CNC is unique among a range of other nanostructured materials due to its benefits such as being a renewable, sustainable, nontoxic, and biocompatible nanomaterial. Due to its nanometric dimensions, large aspect ratio, and excellent mechanical and chemical properties, CNC has many potential applications in many areas, including materials science, electronics, and medicine. The emerging industrial extraction processes to obtain CNC in large quantities need to be optimized to achieve greater yield and quality. So far, most of the research has focused on characterizing the morphological, mechanical, optical, and liquid crystalline properties of CNC, but exploring various surface modification processes to manipulate the functionality of CNC without affecting its inherent properties will be the main focus of future research. This approach will make CNC attractive for use in a wide range of industrial applications, such as high-performance biodegradable material science, electronics, biomedical engineering, drug delivery, catalysis, etc. Innovations in this area may lead to versatile nanomaterials with improved properties. In polymer nanocomposite systems, attaining uniform dispersion and distribution of CNC in a polymer matrix is still a challenging issue, as aggregation or agglomeration is commonly encountered. A tailor-made chemical modification process is necessary to incorporate CNC into different polymer matrix systems effectively. Innovations in nanotechnology related to renewable nanomaterials such as CNC are anticipated to provide technologically advanced products that are not harmful to the environment.

References

1. A.K. Bledzki, J. Gassan. (1999) Composites reinforced with cellulose based fibers Prog. Polym. Sci 24: 221-274.
2.]- K. Ku, H. Wang, N. Pattarachaiyakoop, M. Trada (2011) A review on the tensile properties of natural fiber reinforced polymer composites Composites: Part B 42: 856-873.
3. I. Siró, D. Plackett (2010) Microfibrillated cellulose and new nanocomposite materials: a review Cellulose 17: 459-494.
4. A. Isogai (2013) Wood nanocelluloses: fundamentals and applications as new bio-based nanomaterials J. Wood. Sci. 59: 449-459.
5. 5. R. Rinaldi, F. Scuth (2009) Acid hydrolysis of cellulose as the entry point into biorefinery schemes ChemSusChem 2: 1096-1107.

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