University of Zabol
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The Thesis Submitted for the Degree of Ph.D (In wood Composite products)

Improvement of properties of green polycaprolactone-based nano composites using nano-crystalline cellulose and polyolactic acid

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The aim of this study was the investigation of mechanical, dynamic-mechanical biodegradability, thermal and morphological properties of poly-capro-lactone/poly-lactic acid/cellulose nano crystal three-component nanocomposites. For this purpose, the nanocomposites were manufactured using casting solution method. Then, mechanical tests including tensile strength, tensile modulus and elongation at break and dynamic-mechanical test including storage modulus, loss modulus and loss factor were performed on nanocomposites. Also, their biodegradability behavior in soil environment was investigated and the results were calculated as weight loss. In order to investigate the thermal properties and calculate the crystallinity percentage of nanocomposites, thermal gravimetric tests (TGA) and differential scanning calorimetry (DSC) were used, respectively. Field emission scanning electron microscopy (EF-SEM) was used to study the morphology of the nanocomposites and infrared spectroscopy (FTIR) was used to investigate possible reactions. Fire properties were reported in the form of weight loss and burning time and physical properties in the form of water absorption. The result showed that with increasing cellulose nano crystal and poly-lactic acid to a certain extent, the mechanical and dynamic-mechanical properties were improved**.** Field emission scanning electron microscopy confirmed the presence of nanoparticles in the nanocomposites and the results of infrared spectroscopy confirmed the hydrogen reaction between the hydroxyl groups of cellulose nano crystal with the carbonyl groups of poly-capro-lactone and poly-lactic acid, as well as the hydroxyl groups and carbonyl groups of both polymers with each other. The result of biodegradability test also showed that with increasing of cellulose nano crystal up to 1 percent, the mass loss of nanocomposites increased strongly, While the addition of 3% cellulose nanocrystals led to a decrease in the mass loss of nanocomposites. Also, with increasing polylactic acid, up to 10%, the mass loss of composites decreased, but adding 20% polylactic acid led to a decrease in the mass loss of composites. By increasing the cellulose nanocrystals to 1%, the crystallinity decreased but adding 3% cellulose nanocrystals increased the crystallinity. Also, with increasing polylactic acid, the amount of crystallinity decreased. The addition of cellulose nanocrystals to polycaprolactone increased its heat resistance, while the addition of polylactic acid reduced this resistance. The results of scanning electron microscopy confirmed the degradation of nanocomposites in the soil. The results of fire properties of nanocomposites showed that the addition of 3% clay nanoparticles to the superior treatment formulation led to the improvement of fire properties. On the other hand, there was no significant difference between the water absorption of nanocomposites.

Key words: Nanocomposite, Biodegradability, Polycaprolactone, Polylactic acid, Cellulose nanoparticles.