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Pectin/Nanocellulose Nanocomposites for Edible Films Applications

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Abstract – In this work, eco-friendly nanocomposites were developed by incorporation of cellulose nanofibers from sugarcane bagasse (CNB) into pectin (PEC) edible films. The PEC/CNB nanocomposites were prepared by casting method and characterized by mechanical tests and thermal analysis (TGA). The results showed that increases in tensile strength and elastic modulus of PEC films were obtained by incorporation of CNB at concentrations of 1 and 5%, Table 1, which is explained by the high aspect ratio value of CNB. Thermal parameters of PEC films were slightly improved by incorporation of CNB. The materials developed in this work shows good properties for edible film applications.

Eco-designed polymeric nanocomposites have been exploited for the development of new packaging materials as alternatives for the reduction of the environmental impact caused by large volume of non-biodegradable plastics in the world. Pectin (PEC) is a renewable and anionic biopolymer with highly complex structure, consisting mainly of poly(α-(1→4)-D-galacturonic acid) segments chain and it is the major component of the residues from agribusiness citrus fruit, notably in Brazil. It has been reported that PEC possesses cholesterol-lowering effect, protective effect in diabetesis, and plays an important role in prevention of cancer progression and metastasis [1], denoting an excellent combination of features for development of biodegradable edible films. While the technological properties of plasticized pectin films can be poor when compared to several commodity polymers, addition of cellulose nanofibers appears as an attractive route for producing eco-friendly PEC-based nanocomposites with improved properties. In this work, the incorporation of cellulose nanofibers from sugarcane bagasse (CNB) into PEC-based edible films was investigated with focus on upgrading their mechanical and thermal properties aiming edible film applications.

Nanocomposite films were prepared by casting method from aqueous solution of PEC at 1% (w/w) using glycerol as plasticizer at concentration of 30% (w/w). CNB obtained by acid hydrolysis with H_2SO_4 was incorporated at concentrations of 1 and 5% (w/w). The mechanical properties tensile strength (TS), elongation at break (EB) and elastic modulus (EM) of films were determined according to ASTM D882-09 using an universal test machine EMIC DL-3000. Temperature of initial decomposition (T_i) and first peak temperature (T_{max}) were estimated by thermogravimetric analyses performed in an equipment TA instrument Q500 using heat rate of 10ºC.min^{-1} and oxidative atmosphere of synthetic air.

Changes in mechanical properties of pectin films were observed after the incorporation of CNB, as shown in Table 1. TS of pure pectin film was increased from 16MPa to 25 and 32MPa by addition of CNB at 1 and 5%, respectively, with decrease of EB from 28% to around of 20%. EM values for nanocomposites were 100% higher in comparison with value of pure pectin film. According Mutjé et al. [2] an aspect ratio (L/D) of the fiber of 10 is the minimum aspect ratio required for a good stress transfer from the matrix to the fibers to promote a significant reinforcement. The L/D of nanofibers utilized in this work has been determined by TEM and the values are around 32 [3], which explain the good reinforcement effect caused by CNB on pectin matrices. In addition, thermogravimetric results showed that T_{max} of pectin films was increased from 220 to 227ºC while little changes in T_i was observed, indicating that degradation profile of pectin films were slightly improved by incorporation of CNB.

Table 1: Properties of pectin/nanocellulose films plasticized with glycerol at 30% (w/w)

Films	TS (MPa)	EB (%)	EM (MPa)	T_i (ºC)	T_{max} (ºC)
Pure PEC	16 ± 2	28 ± 1	257 ± 41	197	220
PEC/CNB 1%	25 ± 4	19 ± 1	615 ± 79	199	228
PEC/CNB 5%	32 ± 5	21 ± 2	834 ± 15	201	227

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