EFFECT OF THE DISPERSION OF CARBON NANOTUBES ON THE MECHANICAL PROPERTIES OF GELATIN FILMS

Maria Alejandra Ortiz Zarama[a], Antonio Jiménez Aparicio[a] Brenda Hildeliza Camacho Díaz[a], Rodolfo Rendón Villalobos[a], Emmanuel Flores Huicochea[a] and Javier Solorza Feria[a],
[a]Centro de Desarrollo de Productos Bióticos IPN, Yautepec, Morelos, Mexico. Z.C. 62731
mortizz0902@ipn.mx

Key words: Mechanical properties, Carbon Nanotubes, Gelatin Films.

Introduction. Natural biopolymers have the advantage of being biodegradable, renewable, inexpensive and easy handling during films manufacture. However, biopolymer films have exhibited relatively poor mechanical properties when compared to traditional polymeric films. Gelatin was one of the initial materials used for biopolymer films formation and continues to be used in film studies (1). The addition of nanoparticles as nanominerals, cellulose nanocrystals or carbon nanotubes (CNT) to biopolymer films, has a great potential of improving its mechanical properties, for instance, it has been reported an increase of hardness and Young modulus in the manufacture of polyhydroxyalkanoate films when using CNT (2). Since CNT are highly hydrophobic and tend to agglomerate, it is necessary to disperse them using tensoactives, so that they interact with the other film components.
Thus, the objective of this work was to evaluate the effect of CNT dispersion in gelatin films, on its mechanical properties.

Methods. A deionized water solution with 0.001, 0.05 and 0.1 % sodium dodecyl sulphate (SDS) (w/w) and 0.001% CNT (w/w), was put an ultrasonic water bath at 60°C for 4 h. Besides, a deionized water solution with 9% gelatin (w/w) and 3% glycerol (w/w) was prepared at 60°C with continuous agitation. The solutions were mixed and were put into the ultrasonic water bath, at 60°C for 1h. The resulting filmogenic solution, was poured on squared Petri dishes (23 x 23 cm), and dried at 45 °C for 24 h. The films were stored for 7 days at room temperature in a dessicator with a saturated solution of NaBr (57% HR). The tensile strength (TS) and the elongation at break (EB) were measured using the ASTM D882-12 and ASTM D638-10. Micrographs were captured using a stereoscopic microscope coupled to a digital camera, using light diascopic with a 1.5X objective and a magnification of 0.75. The micrographs were binarized and an image analysis was done.

Results. It is observed in Fig.1 that the increment of SDS concentration, increase the CNT dispersion. Since no difference in the percentage area between the different concentrations of SDS is observed, this is an indication that the films have the same amount of CNTs (Table 1), but the lacunarity shows a better dispersion with the increased SDS concentration**.** The increment of SDS concentration raised the values of EB (Fig. 2) and reduced the values of TS (Fig.3).

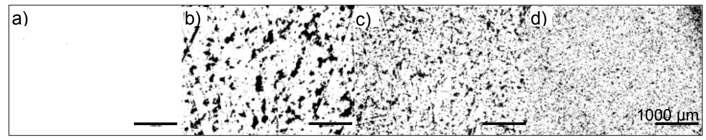

Fig 1. Binarized photomicrographs of the films surface of a) Control b) 0.001% w/w SDS, c) 0.05% w/w SDS and d) 0.1% w/w SDS.

Table 1. Textural parameters obtained by image analysis of films

	Area (%)	**Lacunarity**
Control	0.469 ± 0.151[b]	0.899 ± 0.0084 [a]
0.001% p/p SDS	35.046 ± 3.349[a]	0.377 ± 0.0514[b]
0.05% p/p SDS	32.103 ± 2.07[a]	0.281 ±0.0147[c]
0.1% p/p SDS	31.543 ± 4.348[a]	0.21 ±0.0285[d]

Different letters in the same column indicate significant differences between the treatments (Tukey; p ≤ 0.05)

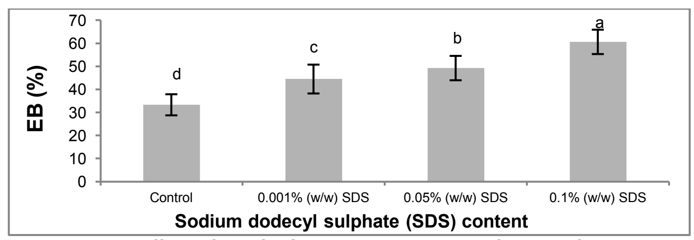

Fig.2 Effect of the SDS content on the EB of gelatin films
Values are the mean of 60 measurements ± standard deviation. Different letters indicate significant differences between the treatments (Tukey; p ≤ 0,05).

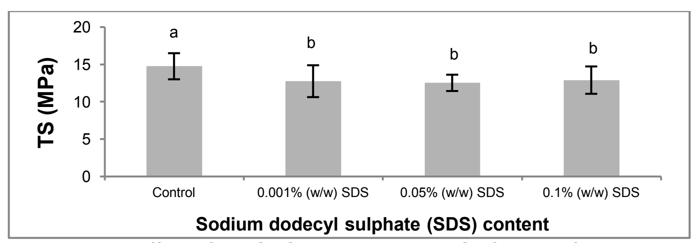

Fig.3 Effect of the SDS content on the TS of gelatin films.
Values are the mean of 60 measurements ± standard deviation. Different letters indicate significant differences between the treatments (Tukey; p ≤ 0,05).

Conclusions. The SDS concentration increase CNT dispersion. The increment of SDS concentration raised EB and reduced values of TS. The better concentration of SDS was of 0.1%.

Acknowledgements. Thanks are due to CONACYT and the PIFI-Instituto Politécnico Nacional program.

References.

1. Bae, H.J., Park, H.J., Hong, S.I., Byun, Y.J., Darby, D.O., Kimmel, R.M., Whiteside, W.S., (2009). Effect of clay content, homogenization RPM, pH, and ultrasonication on mechanical and barrier properties of fish gelatin/montmorillonite nanocomposite films. LWT-*Food Sci Technol.* vol(42): 1179-1186.
2.Yun, S., Gadd, G., Latella, B., Lo, V., Russell, R., Holden, P., (2008). Mechanical Properties of Biodegradable Polyhydroxyalkanoates/Single Wall Carbon Nanotube Nanocomposite Films. *Polym Bull.* vol (61): 267-275.