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Mechanical properties of Ag-Clay nano films

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ABSTRACT

Mechanical properties of seven types of Ag - clay nano films were investigated. Elasticity of Modulus, Tensile Strength, Toughness, Elongation at break, Tear Strength and color of nano films were compared with those of the regular Low Density Poly Ethylene film. Results showed that inclusion of nano particles increased Modulus of Elasticity, Tensile Strength and Tear Strength but Elongation at break point and toughness of the films were decreased. The effect of film type on Modulus of Elasticity, Tensile Stress and Tear Strength, were significant at the 0.01 level and for Elongation at break point and toughness was significant at the 0.05 level. Investigation of film color parameters and ΔE showed that the 1000 ppm nano Ag film has more color than other films. The smallest ΔE was related to the control film. ΔE value of the nano Ag films increased with increasing nano particle content and in nano composite films, decreased with increasing clay content. In sum, the nano film with 1000 ppm nano Ag content was the best film and control film was the worst film. In conclusion, the nano composite film (SC3) with 500 ppm nano Ag- 450 ppm nano clay content was the best film in terms of the mechanical properties.

Introduction

Investigation of simplest packaging production system with nano-technology, issues related to Biosafety and transfer capability of nano particles to the packing of food products and economic use of these packages are important issues that should be taken under studed in Iran (Tajaldin, 2003). Many researches has been taken to improve properties such as dimensional stability, stiffness, strength and other physical and mechanical properties of polyethylene to maintain a competitive position in this matter through engineering applications. The goal achieved by making composites of polyethylene fiber amplifier and through new technologies and processes shaping such materials and preparation of specific compounds and filled to create and produce a new species of polyethylene. The mechanical and optical characteristics of zirconia-carbon nanocomposite films have been studied (Laidani et al, 2008). Results indicated that modulus change due to the change in carbon content. In other studies, Misjak et al (2007), mechanical and structural properties of nano-composite films of Ag - copper were studied. Films under the interval and under full vacuum thermal vapor pressure were made. Results indicated the more Ag percentage increased the more mechanical properties changed. Maximum hardness obtained for the composition contains about 20 percent nano Ag in 4MPA. Analysis of mechanical and permeability characteristics and rheological polypropylene based nano-composite films by Lotti et al (2008), indicating increased modulus 95 percent and decreased of oxygen and water vapor penetration rate, 60 and 45 percent respectively. Also increased ٪ Elongation at break rates (EB).Wang et al (2008), making films nc-TiC/aC: H began using dual plasma technique and the mechanical properties and structure were investigated, which results from the increase of high modulus and hardness in limit, was 510MPA and 66.4 MPA respectively. Based on Cao et al results (2008), the effect of thick film nano ZnO on the elastic properties, showed that increasing thickness, modulus of nano-ZnO film decreases. Physical and mechanical characteristics of a variety of nano-composite films under the influence of nano-clay particles has been reported recently (Viviana et al., 2008). Tensile test was performed on films and the results showed a significant effect of clay particles on the modulus increas to 500 percent. Li Ji et al (2008), use X Rays to investigate the mechanical properties of nano composite Mo/DLC and they concluded, this method is useful for hardness and modulus of elasticity. X-rays can be used as a tool in estimating the exact number and value of the mechanical properties of nano-films. Nano composites or nano-films can be improved heat-resistance properties and mechanical strength and decrease the rate of gas transfer. Nano-films with antibacterial properties due to Ag particles and less oxygen and water vapor permeability due to clay particles than control films, have a significant role in the storage of packaged food, shelf life increase and prevention of stale such as bread products, Improvement of mechanical properties, and permeability reduction of water vapor out of the package, resulted in freshment of packaged food and increase of its shelf life (Sattari Najaf Abadi et al, 2009). In this study, nano-films for food packaging were made and tested. Based on literature review, there is no field with the report of structure nano Ag - clay films by other researchers. The mechanical properties of nano-films for food packaging were studied and the results were analyzed statisticaly using SPSS software.

Methods and Materials

In this study, the mechanical properties of seven type nano films were studied and the results were compared with the control film (without nano particles). Used films based on polyethylene (LDPE), 0.75 degree and master batch containing 20 percent Ag, which were produced under the temperature 195-165 degrees Celsius, 50rpm speed, and interaction method.

Table 1, shows the structural of nano films. Range of Ag particles in this research was between 250ppm to 1000ppm and

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Range of clay particles was between 150ppm to 450ppm (Anon, 2008).

Table 1. Structural of nano films

No.	Symbol	Structural
1	W	Control film
2	S 0.5	250ppm Ag
3	S 1	500 ppm Ag
4	S 1.5	750 ppm Ag
5	S 2	1000ppm Ag
6	SC 1	500ppm Ag + 150 ppm Ag
7	SC 2	500ppm Ag + 300 ppm Ag
8	SC 3	500ppm Ag + 450 ppm Ag

Film thickness and grain size

A hand-held Mitotyo micrometer was used to measure film thickness to an accuracy of 0.001 mm. ten measurements were made at diferent locations on the film and an average value was calculated.

For determination of the structure of the Ag and Clay system, thin (around 40 nm) layers were deposited onto an a-C layer substrate supported by TEM microgrid, which was transparent in transmission electron microscope (TEM). Structural characterization was carried out by conventional TEM using Philips CM-20 microscope at 200 keV.

Mechanical peoperties of nano-films

Samples were analyzed with a ZWICK instrument (Stable Micro systems, 2.5H1S WN: 150888) in the tensile mode operated at ambient temperature and a crosshead speed of 100mm/min. Young's modulus (E), tensile strength (smax), % elongation at break (% EB) and toughness of nano films were calculated from load-deformation curves of tensile measurements. Measurements represent an average of at least eight samples (Mohsenin. 1970). According to ASTM standard method D882-01 (ASTM, 2001), Samples were conditioned at 25º C and 50±3% relative humidity in a desiccator containing Mg (NO3)2 saturated solution for at least 2 days prior to analysis.

Results

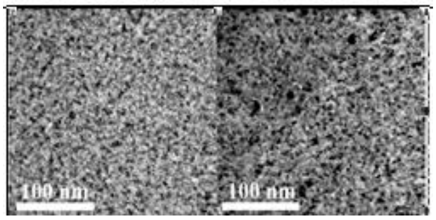

Figure 1. Lateral TEM view and selected area diffraction pattern of a nanocomposite clay–Ag

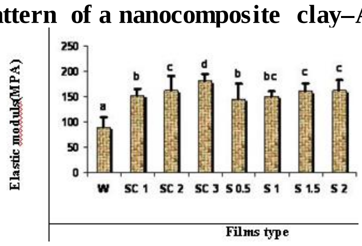

Figure 2. Relationship between films type and Elastic Moduls

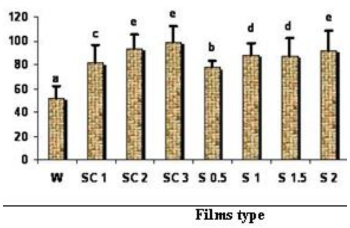

Figure 3. The relationship between films type and Tensile Strength

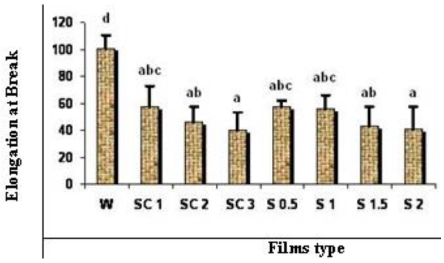

Figure 4. Genre relationship with films type and the Elongation at Break

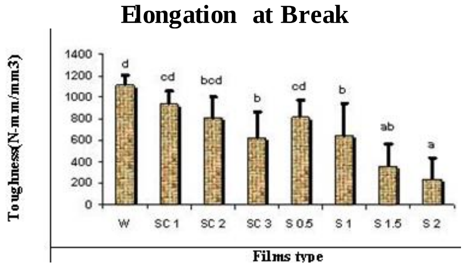

Figure 5. The relationship between films type and Toughness

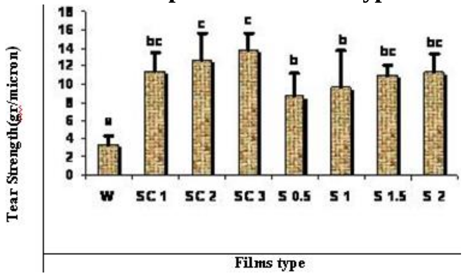

Figure 6. The relationship between films type and Tear Strength

Table 2. Relationship types of nano-films with the color features

Films type	L*		a*		b*		ΔE	
	average	σ	average	σ	average	σ	average	σ
w	92.40[d]	±0.16	-1.47[a]	0.04	1.6[a]	0.06	0.50[a]	0.07
s 0.5	91.26[cd]	±0.89	-0.91[a]	0.47	3.47[ab]	0.09	2.55[ab]	1.38
s 1	89.44[bcd]	±1.05	0.38[b]	0.90	5.49[b]	1.75	5.40[b]	2.20
s 1.5	87.44[bcd]	±2.68	1.32[bc]	0.48	8.37[c]	1.07	9.09[c]	2.45
s 2	82.52[a]	±6.17	3.52[e]	1.02	14.66[d]	2.21	14.07[d]	2.01
sc 1	86.02[ab]	±0.70	1.61[d]	0.28	9.65[c]	0.55	11.17[c]	0.86
sc 2	86.80[abc]	±0.64	2.26[d]	0.21	8.97[c]	1.32	10.79[c]	2.06
sc 3	87.68[bcd]	±1.18	3.56[e]	0.50	8.57[c]	1.33	9.13[c]	1.63

Averages with the same letters in each column, were not significant at 0.05 levels.

σ: Standard deviation

Discussion

-The grain size of both Ag and Clay is below 10 nm and the rings in the diffraction pattern broaden correspondingly. Simultaneously a very strong texture appears in both components (Ag and Clay). Tilting of the specimen in the TEM leads to the breaking of the diffraction rings into arcs, directly proving the existence of the texture (figure 1).

- using nano-particles in LDPE film, increased the Elasticity of Modulus. The nano film with 3percent of clay (SC3), has the highest modulus of elasticity and control films, has the lowest modulus of elasticity. With Using of nano particles, the elasticity modulus was increased 1.5 to 1.9 times. The effect of film type on Elasticity of Modulus was significant at 0.05 levels (figure 2).

- using the nano-particles in the film LDPE, the tensile strength increased 1.4 to 2.1 times. Maximum tensile strength related to nano- films with 3percent of clay (SC3) and the lowest tensile strength was related to the control film. The effects of film type on tensile strength were significant at the 0.05 level (figure 3).

- ٪Elongation at break with using nano-particles, has been reduced. Maximum ٪Elongation at break rates for control film and lowest of ٪Elongation was related to nano film with 3percent of clay (SC3). Types of nano-films on the percentage rate of ٪Elongation at break were significant at the 0.05 level. The used of nano materials, reduced ٪Elongation at break 1.4 to 2 times (figure 4).
- using the nano-particles in LDP film E, Toughness has been reduced. Maximum Toughness rates were related to 2 percent of nano Ag (S2). The use of nano materials reduced Toughness rates from 1.3 to 4.2 times. Types of nano-films on Toughness were significant at the 0.05 level (figure 5).
- using the nano-particles in LDPE film, the tear strength was increased significantly. Maximum tear strength was related to nano film with 3percent of clay (SC3). The use of nano materials was increased tears strength 2.5 to 4.1 times. Also, the effect of film type on tear strength was significant at 0.01 levels (figure 6).
- By testing the three different color and get the overall color films (ΔE), it was found that nano-Ag film (S2) compared to other films has more color. Lowest overall color differences related to the control film. Total color differences in the films of nano Ag, with Ag was increased with rising percentage, but the film combined with increasing clay percentage, was decreased (table 2).
- Overall, the nano film with three percent clay (SC3) was the best film relates other films. The major problem of SC3 film was the dark color due to clay particles that may was important for some packages such as food product.

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