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Effect of LDPE/MWCNT films on the shelf life of Iranian Lavash bread

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ABSTRACT

Bread packaging is one of the important techniques to postpone bread staling. In this research effect of multi walled carbon nanotube (MWCNT) / LDPE nanocomposite films was investigated on shelf life of bread. Results showed that by increase in amount of CNTs, barrier properties were changed and permeability of oxygen and water was decreased in nanocomposite in comparison with blank sample. The lower levels of water permeability in nanocomposites postpone hardening of breads. In other hand the antibacterial property of CNTs and the lower levels of oxygen lead to decrease in rate of mold growth. All these effects make MWCNT / LDPE films as an appropriate package for bakery products.

Keywords: Bread, Nanocomposite Packaging, Carbon nanotube, Shelf life

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INTRODUCTION

Bakery products are the most important type of processed food worldwide and a lot of people in the world use bread as their staple food [9]. There are several category of bread in the world that are so different from each other in containing material and the method of preparation [10]; but all of breads are the same in one case after being baked which is staleness so it can't be used for long time [12]. There is no specified method to prevent bread from staling but it can be postponed by using several techniques [11].

One of these techniques is using the appropriate packaging like active packaging [8]. This kind of packaging can increase the shelf life of the bread by controlling the oxygen and water vapor permeability and inhibition of mold growth on bread's surface [6].

Carbon Nano tubes (CNT) is one of the interesting materials that could be compounded to polymer matrix, to make a kind of active packaging. CNTs could improve barrier properties of films. It can also have strong antibacterial function so it can control the mold growth on bread [1].

There are several methods to prepare polyethylene / CNT Nanocomposite film; for example Sol- Gel, Template, Melt intercalated method, In-situ polymerization and Solution casting method [2][14].

Solution casting is the oldest method to manufacture polymer films. Nowadays this method can be used to prepare Nanocomposite film by using ultrasonic direct mixing, to disperse Nano particles in polymer matrix. The films prepared by this technique have high quality and they are increasingly attractive for scientists be used in laboratories [13].

MATERIALS AND METHODS

Materials

Multi walled carbon nanotube (purity>99 wt %) – low density polyethylene granules (LDPE) – Xylene solvent (Merck) - traditional Lavash bread – Potato Dextrose Agar (Merck)

Equipment

Texture Analyzer - Incubator – digital balance (0/001gr readability) – Ultrasonic bath (Elmasonic) –Vapometer Permeability Cup – Gas permeability tester

Methods

Sample preparation

PE films with 0.1%, 0.3% and 0.5% of multi walled carbon nanotube (Fig1) were prepared by a solvent casting technique in m-Xylene with a weight ratio of 1:20 at 100°C for an hour. MWCNTs were dispersed in 5% LDPE / 95% Xylene solution (0.1, 0.3 and 0.5 wt% MWCNT in LDPE) by ultrasonic disruption for 30 minutes. Thin films were cast in glass dish and the Xylene removed by evaporation at 80°C for 8 hours. Then it was put at room temperature for 48 hours. Finally the dish was immersed in water to separate film from glass dish. Blank films (5% LDPE in Xylene) were also cast by the same technique [7].

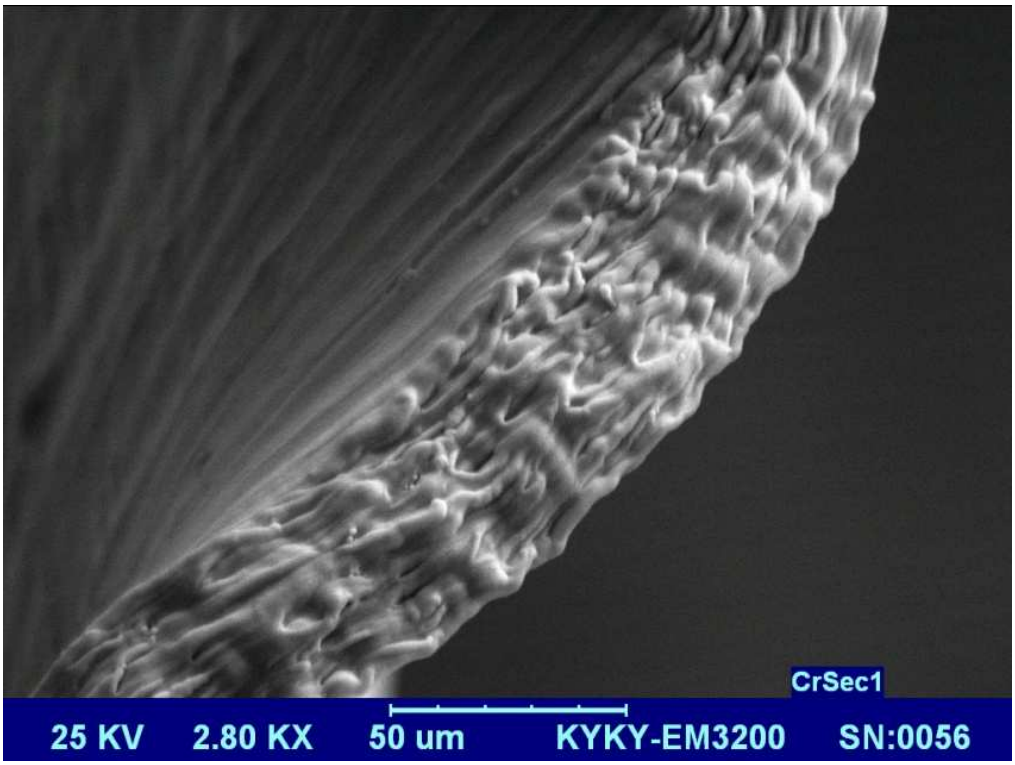


Figure 1 : SEM image of cross section of nanocomposite

Examination

Vapour permeability

The water vapour permeability of films was examined according to the ASTM E96-95 standard by vapometer permeability cup. In this method weigh loss was controlled during the test. Then water vapour permeability derived from this equation

$$wvp = \frac{\Delta m.\, x}{A.\, \Delta T.\, \Delta P}$$

In which, WVP is water vapour permeability, Δm(gr): weight loss of each cup, x (m): thickness of the film. A (m^2): contact area. ΔT(s): Time, ΔP(kpa): partial pressure difference between inside and outside of the cup [5].

Oxygen permeability

Oxygen permeability was measured by gas permeability tester and it was performed by standard method of ASTM D1434, 1990. In this test, the gas rate was 100cm^3/min, the environment moisture was 35% and the temperature was 23^{o}c [4].

Texture analyze

30 seconds after being baked, bread was placed in prepared films and packed by heat seam. Samples were put in room temperature. The texture analysis was examined in 1th, 5th, 7th, 14th and 21th day after packaging according to the AACC 74-09 standard by texture analyzer. The maximum force in analyzer was 500N, the rate was 60 mm/min and the sample diameter was about 3 mm [3].

Microbial test

Mold counts were measured in 14th and 21th day of sample storage according to the standard method on potato dextrose agar medium.

RESULTS AND DISCUSSION

Water permeability

The study showed decrease in permeability by increasing the amount of MWCNT in LDPE films. The value was different between 2.4×10^{-9} (g/m.s.pa) for control sample to 1.02×10^{-9} (g/m.s.pa) for 0.5% carbon nanotube sample. These values are shown in chart1.

Oxygen permeability

The average oxygen permeability rates of the films are shown in chart 2. According to this chart adding MWCNT in LDPE films inhibited oxygen permeability significantly. These values were about 1009, 921 and 800 (cm^3/m^2 d bar) respectively for samples with 0.1% - 0.3% and 0.5% MWCNT whereas 1327 (cm3/m2 d bar) for control sample.

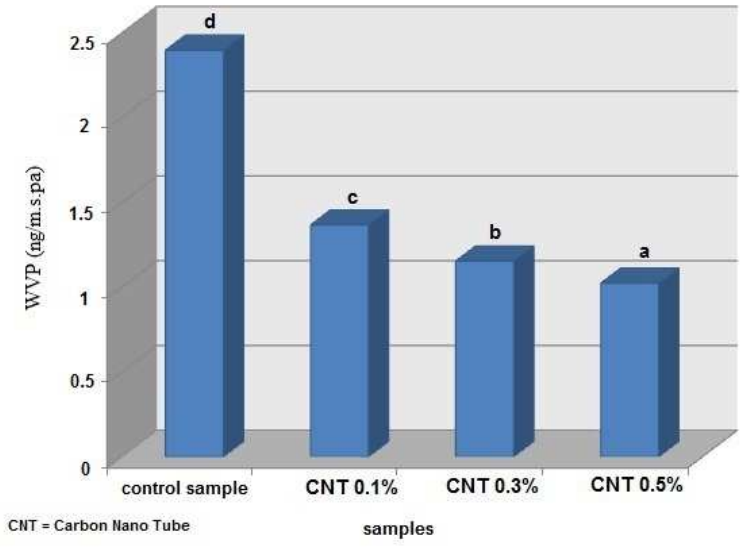


Chart 1: Water vapour permeability

The van der Waals volumes of oxygen and water are the same, however, the penetration mechanisms of water and oxygen in a flexible polymer are different, mainly because of their different polarity (which allows the formation of water clusters, for example. Because of the formation of water clusters (which increase the penetrating volume) the main transport controlling mechanism could be the diffusion thru the polymer. Oxygen clusters volume is smaller than the water clusters and the main transport controlling mechanism could be thru the polymer.

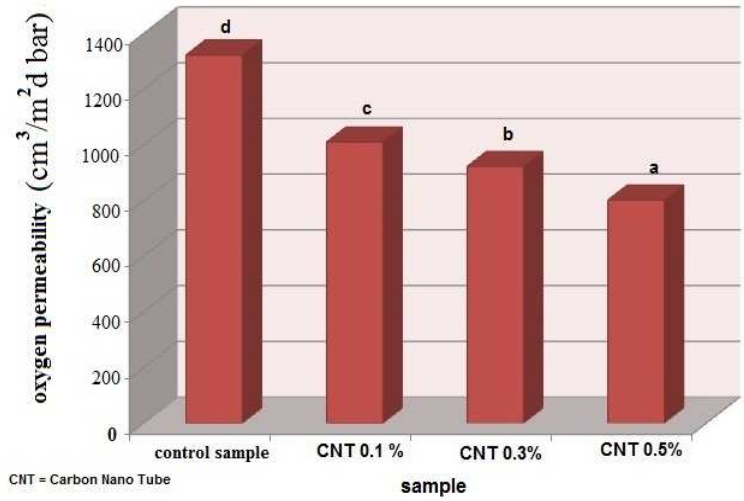


Chart 2: Oxygen permeability rate

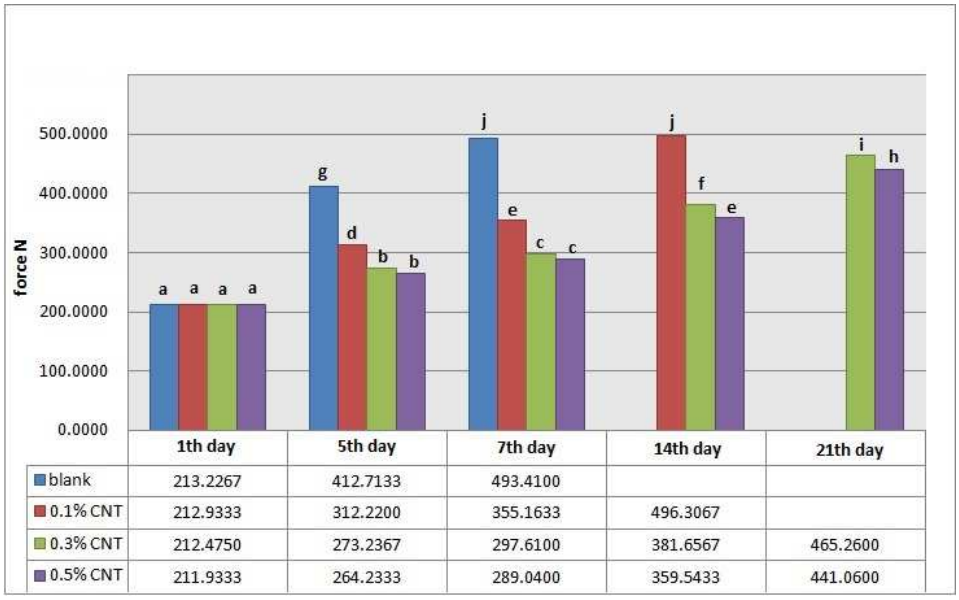
Texture analyze

The average forces to cut each category of samples during the examination days are shown in chart 3.

According to this chart samples in the first day don't show any statistically significant difference. This means samples were the same together and packages didn't have any especial effect on staleness during the first hours. After that the blank sample's graph's upward trend increased faster than the others as a sign of high hardening rate while in the other samples the rate of hardening reduced by increased in amount of CNTs. The samples had been put in 0.3% and 0.5% CNTs packaging didn't show any statistically significant difference during the first week. But after that they showed a slight difference. This difference between ratio rates of hardening in samples depended on ability of packaging to control water vapour permeability. Each one of the samples that needs more than 500 N (for cutting samples) were removed from examination so the blank sample was removed in 14^{th} day and the samples by 0.1% CNTs were removed in 21th day of examination.

Microbial test

Mold count was done in 14^{th} and 21th day of the examination and the average result was shown in chart 4. According to this chart, the rate of mold growth was reduced by increase in amount of CNTs but in 21th day of examination there wasn't any statistically significant difference between 0.3% and 0.5% CNTs packaging. It means that packaging containing 0.3% CNTs had an acceptable property against molds growth during the examination.



	1th day	5th day	7th day	14th day	21th day
blank	213.2267	412.7133	493.4100		
0.1% CNT	212.9333	312.2200	355.1633	496.3067	
0.3% CNT	212.4750	273.2367	297.6100	381.6567	465.2600
0.5% CNT	211.9333	264.2333	289.0400	359.5433	441.0600

Chart 3: texture analysis

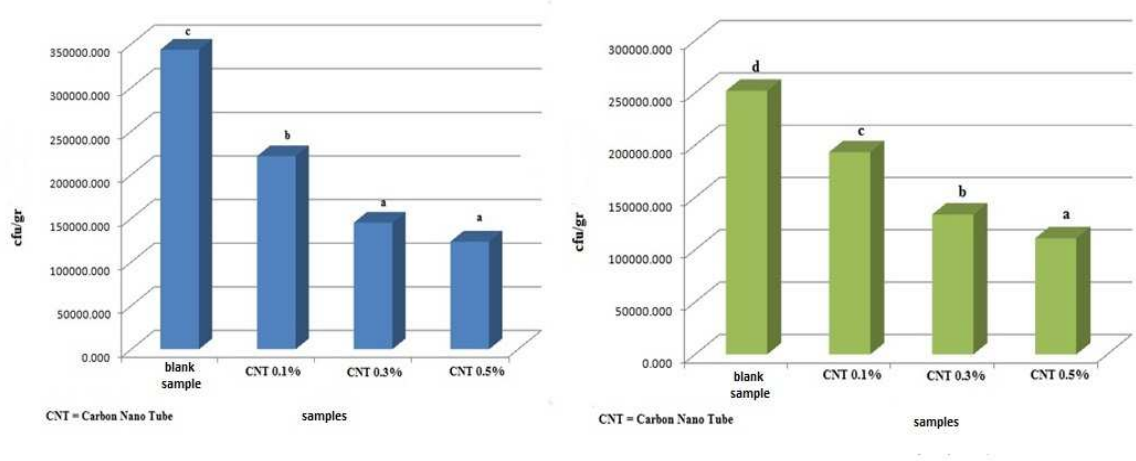


Chart 4: Mold counting in 14th day (on the right) and 21th day (on the left)

CONCLUSION

Use of carbon Nano tube in polyethylene film causes a significant effect on water vapour and oxygen permeability of CNT/LDPE films. It can be used in special food packaging such as MAP or package of some foods that have to be kept away from environmental moisture or oxygen and it's suitable for keeping fruit and bread fresh and to prevent them from losing their moisture and increasing their shelf life.

The result showed the rate of hardening was reduced by increase in amount of CNTs so the 0.5% CNTs samples had the lowest rate among the other ones. The 0.3% CNTs samples had an acceptable function in comparison with 0.5% CNTs samples.

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