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IMPA

Analysis of Physical and Antibacterial Properties of Polyethylene Nanocomposite Films Containing Zinc Oxide Nanoparticles Authors

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Abstract

In this paper, the production of nano-composite films based on low density polyethylene containing zinc nanoparticles and their physical and antibacterial properties have been studied as active films in food packaging. In this paper, zinc nanoparticles with 3 and 7 wt.% Were added to polyethylene films prepared by the melt extrusion method. For better propagation of particle nanoparticles in nanocomposites, maleic anhydride (the most conventional compatibilizer in polymer compositions) was used, which investigated the failure surface of nano composite with an electron microscope. Thermal stability of films was investigated with DSC device. It was observed that the thermal stability of the polyethylene film is more than zinc nano composites and the thermal stability of compatibilizer nano composite films is more than polyethylene. Antibacterial properties were evaluated using colony counting method. The reduction number of Staphylococcus bacteria is more than E.coli, this effect is more in non-compatibilizer films.

Introduction

Using nanoparticles produces favorable properties in composites. The nano composites include antibacterial nano composites, physical resistant nano-composites, or thermally-resistant nano composites.. The purpose of the active packaging is to increase the protection of food and drink in the package. The key to the active packaging definition is that, in addition to the primary goals of each package. the inclusion, protection, ease of use and communication, it has another important role in food products. Zinc nanoparticles also have antibacterial properties and advantages such as cheap prices, white appearance, and ultraviolet resistance to silver. They also have a variety of applications and can be loaded onto minerals such as apatite hydroxide and show antibacterial activity against a variety of bacteria..

Experimental

Materials:

In this research, low density polyethylene was used in Bandar Imam Petrochemical Company. ZnO nanoparticles a product from Nano Amor company in Italy with an average particle size of 40-60 nm and a maleic anhydride compatibilizer were purchased from Ariya Polymer Pishgam Co.

Preparation of nanocomposite films:

For mixing the raw materials and the extrusion process and the preparation of the desired nanocomposite, an extruder was used. The temperature of the various areas of the extruder from the feeding sector to the outlet was adjusted at 125, 145, 155, 170, 185, 195, 195, and 200 degrees centigrade, respectively. The extruder pressure was 12.5 bars and the melting temperature was 200 degrees centigrade. polyethylene and metal nanoparticles (in percent by weight 3, and 7%) in the presence and absence of the dispersant are well mixed and fed into the extruder container through a funnel.. The temperature of the different regions of this extruder was 239, 239, 223, 223, 218, 215, 185 degrees centigrade, respectively.

Result & Discussion

As shown in Figures 1 and 2, the particle size of nano-oxide zinc is between 40-60 nm.
Pure light polyethylene (A)
Nanocomposite with 3% zinc oxide (AD 3)
Nanocomposite with 3% ZnO and 1% compatibilizer (AD3B)
Nanocomposite with 7% ZnO (AD7)
Nanocomposite with 7% ZnO and 2% compatibilizer (AD7B)
Figure 3 shows the morphology of the homogeneous failure surface of pure polyethylene in comparison with nanocomposite samples. The almost heterogeneous failure surface of nanocomposites can indicate a change in tissue due to the presence of metal nanoparticles. The morphology of the homogeneous failure surface of pure polyethylene is shown in comparison with nanocomposite samples. The almost heterogeneous failure surface of nanocomposites can indicate a change in tissue due to the presence of metal nanoparticles. As can be seen, by the addition of the compatibilizer, distribution of nanoparticles is approximately suitable, and aggregation and agglomeration in different regions of the failure surface are apparently not observed.

Results of mechanical properties measurement:
As shown in the chart, the elongation at breakage of samples containing zinc oxide nanoparticles is lower than the specific polyethylene, and in comparison with the compatibilizer samples, have a longer elongation and suggests that the compatibilizer is capable of proper nano-particle spreading and performance, and strong chemical bonding between nanoparticles and polymer tissue and proper spreading of nanoparticles has resulted in appropriate transfer of applied stress.

Results of microbial tests:
As shown in Table 1, the antibacterial activity percentage of synthesized compounds indicates that nanocomposite samples without compatibilizer have less antibacterial activity than those with compatibilizing samples. Antibacterial activity is also increased by increasing the percentage of Nano ZnO. By comparing these two charts of Staphylococcus aureus and Escherichia coli, it has been shown to be more antibacterialagainst E. coli bacteria. Due to the difference in the cell wall of the gram-positive and gram-negative bacteria, such resistance is predictable from gram-positive bacteria against antibacterial agents.

Results of thermal stability test:
As shown in the figure, the thermal stability of nanocomposites without compatibilizer is less and composite containing compatibilizers are approximately twice that of pure polyethylene, and the presence of a compatibilizer and nanoparticle delayed the polymer's degradation.
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Results of thermal stability test:
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Conclusion

lower percentage of elongation than polyethylene, but with increasing nanoparticle percentage, the strength decreases and the elongation at breakage increases.

Thermal stability (non-degradation of polymer) in nanocomposites without compatibilizer is less than pure polyethylene and in compatibilizer nanocomposites is more than other samples, which improves with increasing percent of nanoparticle and compatibilizer. Antibacterial activity of samples containing nanoparticles and compatibilizers is more than pure polyethylene and non-compatibilizer samples. This activity was observed in reducing ECOLI bacteria more than S. aureus bacteria.

References

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Table & Figures

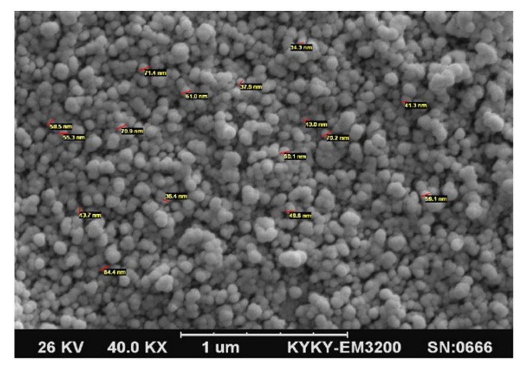

Figure 1 : SEM image of the particle size of the nano-oxide zinc

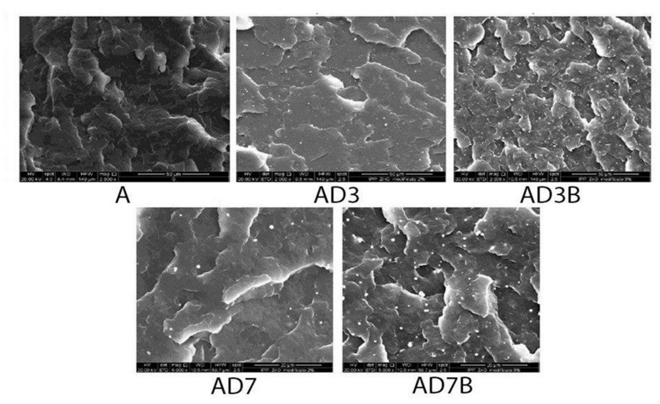

Figure 3: Electron microscopic images of samples

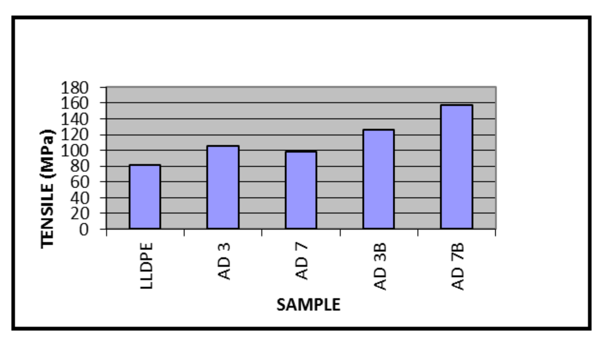

Figure 4 : Comparison of tensile strength of nanocomposite films

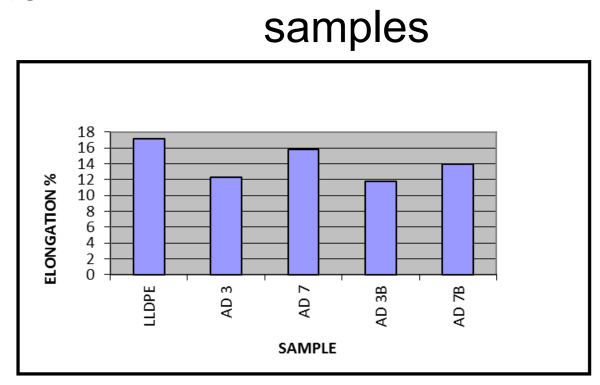

Figure 5 : Comparison of elongation at breakage of nanocomposite films

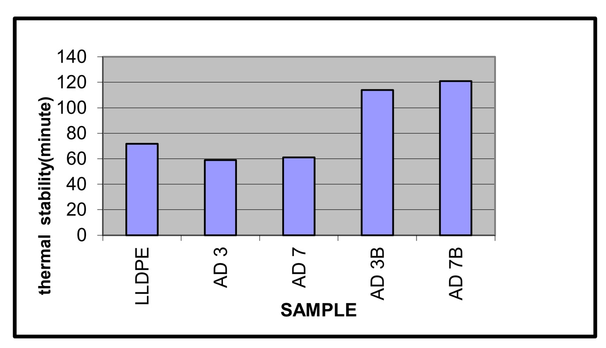

Figure 6 : Comparison of thermal stability of nanocomposite films

Number of s.aureus bacteria after 24 hours	Number of s.aureus bacteria immediately after fertilization	Number of ECOLI bacteria after 24 hours	Number of ECOLI bacteria immediately after fertilization	sample
2.8×106	3.8×106	3×106	4.4 ×106	LLDPE
2.2×106	3.8×106	1.2×106	4.4 ×106	AD 3
1.9×106	3.8×106	1.3×105	4.4 ×106	AD 7
1.8×106	3.8×106	1.2×104	4.4 ×106	AD 3B
1.5×105	3.8×106	1.1×104	4.4 ×106	AD 7B

Table 1 : Number of bacteria count in the presence of nanoparticles after 24 hours