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Nanocomposites in Food Packaging

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Abstract: ***In this project work we report that extending the shelf life of paneer by blending the LDPE/Nanocomposites using twin screw extruder to increasing the mechanical properties as tensile strength, burst strength and barrier properties as oxygen transmission rate, water vapor transmission rate using montmorillonite and organic montmorillonite nanocomposites. The antimicrobial agent as Nisin is coated over the nano film to increase the anti-microbial properties. The XRD which indicated the different levels of intercalated structures for the nanocomposites. SEM analysis indicates the degree of dispersion of nanocomposites over the LDPE film. The results indicated that organic MMT/LDPE material which gives more tensile, mechanical properties and barrier properties and it increases the shelf life of paneer.***

Index Terms: ***Nanocomposites, Mechanical properties, Polyethylene, Coating, Polymer blends***

I. INTRODUCTION

Paneer is widely consumed in Indian market. It is rich in minerals, calcium and fats. It used in stuffing material for various vegetable dishes, snacks and sweet meats. In small scale industries it is widely packed in low density polyethylene (LDPE). The normal shelf life of fresh paneer is 7 days at 4˚C. The extension of shelf life of fresh paneer will be very helpful for the small scale manufacturer of paneer. Nanoparticles are widely used in packaging applications as they improve the barrier properties against oxygen and moisture. Nanocomposites also control the rate of deterioration and thus extend the shelf life of the food. Antimicrobials in food packaging are used to enhance quality and safety by reducing surface contamination of processed food. Antimicrobials reduce the growth rate and maximum population of microorganisms (spoilage and pathogenic) by extending the lag phase of microbes or inactivating them. Antimicrobial agents may be incorporated directly into packaging materials for slow release to the food surface or may be used in vapor form. The aim of this investigation work is to extend the shelf life of paneer. The LDPE-MMT nanocomposite prepared by melt processing method is chosen as the polymer nanocomposite for improving the barrier properties. Nisin is chosen as the antimicrobial agent as it can inhibit the growth of microorganisms present in paneer. The LDPE-MMT nanocomposite film with nisin as an antimicrobial coating will be fabricated and tested for mechanical, barrier, and migration. The XRD and SEM. analysis that indicates the dispersion of nanocomposites over the LDPE film.

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II. EXPERIMENTAL

2.1 Materials

Low density polyethylene (24FS040) has density of 0.922 g/cm^3, melt flow index of 4g/cc has a properties to blended with such copolymers as ethylene-vinyl acetate, ethylene-ethyl-acrylate and nano clays to further extend and improve its properties. It has a good transparency, but cannot be made crystal clear. In thick-walled containers it is translucent and waxy in appearance. Easily pigmented, any opaqe color can be used in bottle resins, but such metallic colors as gold, silver, and bronze do not show very good brittliance. It has an excellent resistance to acids, bases and vegetable oils in packaging.

MMT (Cloisite Na^+) is untreated natural clay that is most commonly formed by the in situ alteration of volcanic ash or by the hydrothermal alteration of volcanic rocks. MMT is widely used as reinforcement for the polymer–clay nanocomposite synthesis because it is environmentally friendly, readily available in large quantities at a relatively low cost. Na-MMT with a cation-exchange capacity of 92.6 milliequiv/100 g of clay was used as a reinforcing agent to prepare untreated nanocomposites.

The organic MMT clays has more organophilic, hydrated cations of clay surface are replaced by cationic surfactants (alkylammonium or alkylphosphonium/ onium) to lower the surface energy. Sodium ions in natural clay are exchanged with an amino acid such as 12-aminododecanoic. The organoclays are surface modified to allow complete dispersibility and miscibility with many different resin systems to improve its properties. It has a specific gravity of 1.77g/cc. The particle size of this silicates are 2 µm.

Nisin is a polycyclic antibacterial peptide with 34 amino acid residues used as a food preservative. It contains the uncommon amino acids lanthionine, methyllanthionine, didehydroalanine and didehydroaminobutyric acid. These unusual amino acids are introduced by posttranslational modification of the precursor peptide. In these reactions a ribosomally synthesized 57-mer is converted to the final peptide. The unsaturated amino acids originate from serine and threonine, and the enzyme-catalysed addition of cysteine residues to the didehydro amino acids result in the multiple thioether bridges.

It is the most commercially important member of a large class of bacteriocins produced by bacteria Lactococcus lactis that can kill or inhibit the growth of other bacteria.

It is a natural antimicrobial agent with activity against a wide variety of undesirable food borne (pathogenic) bacteria. Nisin is used as a preservative in heat processed and low pH foods. Nisin cannot be synthesised chemically, so the nisin-producing L. lactis bacteria are used for the synthesis of nisin.

2.2 Sample Preparation

LDPE and 5% of MMT is mixed and blended by using twin screw extruder. It has eight different zone. Different temperature is maintained in each zone (zone 2 =110˚c, zone 3 = 130˚c, zone 4 = 150˚c, zone 5 = 160˚c, zone 6 = 170˚c, zone 7 = 185˚c and zone 8 = 200˚c). The blended polymer granules is made at end of the process. The preparation process is same for to blend LDPE and OMMT.

2.3 Experimental methodologies

The granules of LDPE-MMT and LDPE-OMMT are made by using twin-screw extruder. After granules are made thin film of 55 micron thickness are made by using Collins blown film extruder.

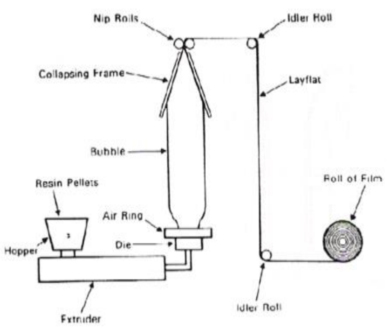

Figure i. Blown film extruder

III. RESULTS AND DISCUSSION

3.1 X-Ray diffraction method

X ray diffraction method is used to measures the spacing between the ordered crystalline layers of the MMT and OMMT clays over LDPE film by diffraction from two scattering planes that are separated by a distance d (d-spacing) at the incident angle Θ. The experimental 2Θ value is the angle between diffracted and incoming X-ray waves. The degree of the diffraction is measured by Bragg law,

$$\text{Sin}\ \Theta = n\,\lambda/2d$$

The XRD patterns of clay reflects that changing of polymer material from crystalline into amorphous due to nano silicates. The penetration of polymer into clay interlayers results in an increase in interlayer spacing and shift of XRD peaks toward lower angles. A further shift to lower angles and expansion of the characteristic XRD peaks are an indication of partial complete intercalation of clay structure.

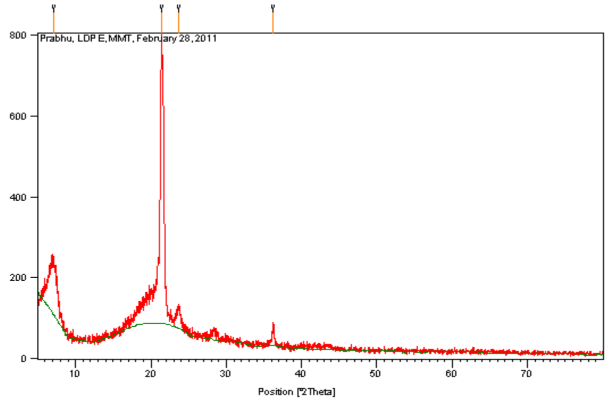

Figure 1. XRD patterns of LDPE-MMT clay.

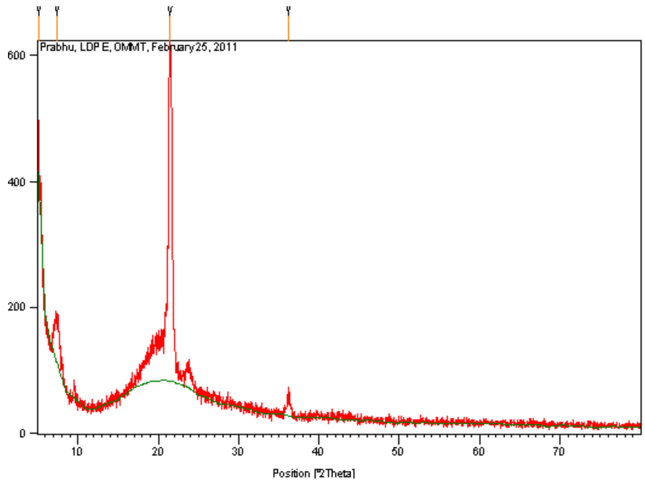

Figure 2. XRD pattern of LDPE-OMMT clay.

The Table 1. Shows that comparative XRD d spacing values between LDPE-MMT and LDPE-MMT nano clays. This results shows that OMMT clays has more degree of dispersion comparative with LDPE-MMT composites.

S.no	POS (2 Θ)	LDPE-MMT (Å)(d spacing)	LDPE-OMMT (Å) (d spacing)
1	5.01	164	440
2	7.93	100	111
3	18.91	116	124
4	20.11	150	158
5	35.21	24	35
6	47.69	17	25
7	58.55	16	19
8	79.89	7	13

Table 1. Comparative d-spacing values.

3.2 Scanning Electron Microscopy

SEM is a technique used to determine the dispersion on the surface of the LDPE film. It is a type of electron microscope capable of producing high-resolution images of a sample surface. Generally SEM images have a three-dimensional appearance and are very useful for the surface morphology of the sample. The spatial resolution of SEM is determined by the electron spot size which in turn depends on the magnetic electron-optical system which produces the scanning beam. Fig 3 and 4 shows SEM micrographs of samples LDPE-MMT and LDPE-OMMT.

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Fig 3.1 OMMT clay polymer matrix

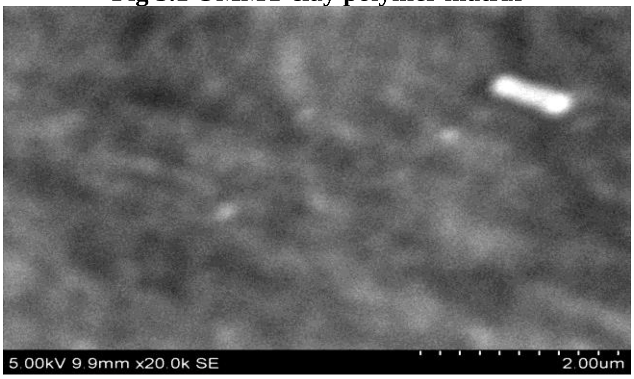

Fig 3.2 OMMT clay polymer matrix

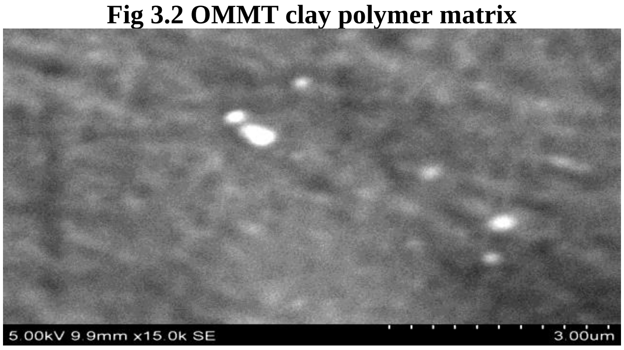

Fig 3.3 OMMT clay polymer matrix

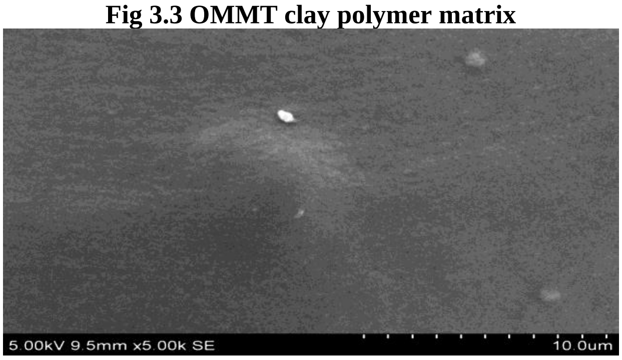

Fig 4.1 MMT clay polymer matrix

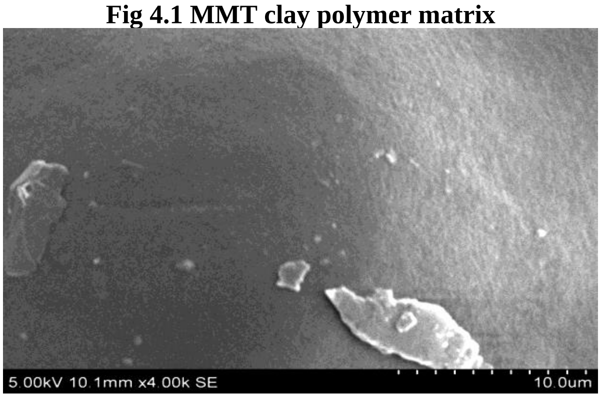

Fig 4.2 MMT clay polymer matrix

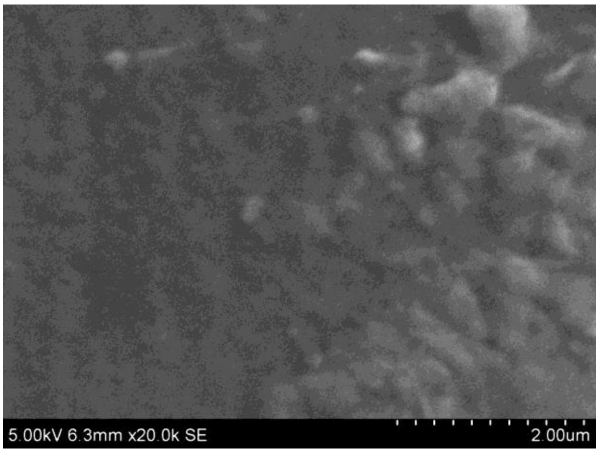

Fig 4.3 MMT clay polymer matrix

On the basis of the figure the OMMT clay polymer matrix have a good miscibility compared with MMT clay polymer matrix. The fracture surfaces of nanocomposites are relatively smooth and the microstructures are fine, suggesting that the clay disperses very well in the polymer matrixes.

3.3 Testing of mechanical properties

3.3.1 Tensile strength test

It is a measure of the ability of a material to withstand force that tend to pull it apart to determine to what extent the material stretches before breaking.

3.3.2 Burst strength test

It is used to determine the burst strength of the polymer films.

Table 2 shows that comparison of tensile and burst strength of virgin LDPE, LDPE-MMT, and LDPE-OMMT clays.

Polymer Material	Tensile strength (MPa)	Burst strength (PSI)
Virgin LDPE	13.54	375
LDPE-MMT	22.02	430
LDPE-OMMT	22.11	450

Table 2. Comparative of mechanical Properties

From the Table 2. The mechanical properties of LDPE-OMMT thin film which is increased compared with LDPE-MMT and virgin material.

3.4 Testing of Barrier Properties

3.4.1 Oxygen transmission test

This test method is used to determine the steady-state rate of transmission of oxygen gas through plastics film.
It also provides the determination of oxygen gas transmission rate (OTR), the permeance of the film to oxygen gas and oxygen permeability coefficient.

3.4.2 Moisture vapour transmission test

It is a measure of the passage of water vapor through a polymer film. Moisture sensitive foods in packaging with controlled MVTR to achieve the required quality, safety, and shelf life.

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3.4.3 Migration test

The migration test is used to determine the transfer of substances from the package to the food (paneer). Substances that are transferred to the food as result of contact or interaction between the food and the packaging material are referred as migrants. A proper food stimulant as n- heptane is chosen and analysed for migration when packed in LDPE-MMT and LDPE-OMMT film with antimicrobial coating. The migration of metenic compound from the films which is noted.

Table 3. shows that comparison of barrier properties LDPE-MMT and LDPE-OMMT

Polymer material	OTR	MVTR (ml/m^2)	Migration (mg/dm^2)
Virgin LDPE	4.76	22.6	-
LDPE-MMT	5.26	36	2.57
LDPE-OMMT	5.53	38.0	1.75

Table 3. Comparative of Barrier Properties

From the Table 3. The barrier properties of LDPE-OMMT thin film which is increased compared with LDPE-MMT and virgin material.

3.5 Antimicrobial coating

One gram of nisin should be suspended in 5 ml of 0.02 N HCl and it will be centrifuged at 15000 g for 5 min. The centrifuged nisin is coated over thin films manually and it has dried in 30˚c by warm air**.**

The paneer has to packed on coated thin films and stored at refrigeration condition on 4˚c. The normal shelf life of paneer is 7 days at 4˚c.when paneer is packed in thin nano fabricated antimicrobial coated films the shelf life of paneer is increased.

Table 4. Shows the shelf life of paneer when packed in LDPE, LDPE-MMT and LDPE-OMMT.

Polymer Material	Shelf life (days)
Virgin LDPE	7 days
LDPE-MMT	13 days
LDPE-OMMT	15 days

Table 4. Comparative of shelf life on paneer

From the Table 4. The shelf life of paneer is incresed upto 15 days when packed with nano fabricated antimicrobial coated film.

IV. CONCLUSION

The nano fabricated LDPE thin film is fabricated on melt compounding and it will incresed in mechanical, barrier properties. The dispersion is evaluated in XRD and SEM method. The migration test showed that suitability for packing the food stuffs.

The coated nisin which increased the antimicrobial properties of thin films and it will incresing the shelf life of paneer upto 15 days.

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