Synthesis of MgO/PVA nanocomposite film and investigation on tensile and antibacterial properties

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1. INTRODUCTION

Polymer nanocomposites have attracted a great deal of interest due to their ability to improve physical properties of polymers such as mechanical and thermal properties [1]. In microcomposites, it was difficult to optimize the physical properties, because intimate and homogenous mixing of guest–host materials is hard to achieve. Hence it is highly desirable to have nanoscopic and even molecular level mixing of guest–host materials, so that it is easier to fine tune the physical and chemical properties, and this could pave the way for several innovative [2] applications. The properties of the polymeric materials can be improved by including refractory or ceramic materials are impregnated into the polymeric matrix. Among the refractory materials to be included in to the polymer, here Magnesium oxide is chosen since it is having lot of applications such as a heat-resistant glass composite in liquid crystal display panels, electroluminescence display panels, and fluorescent display tubes[3]. Recently, it was reported [4] that MgO had good bactericidal performance due to the formation of O^{-2} anions at its surface in aqueous solution. It exhibits high bactericidal activity against bacteria, spores and viruses [5]. The advantage of MgO nanoparticles is that it possesses high surface energy, which could be dispersed in organic solvent and matrix easily.

One of the conventional methods of preparation of polymer nanocomposite includes generation of nanoparticles inside the polymer matrix in an *in situ* manner. In this paper we report the synthesis of MgO/PVA nanocomposite by sonochemical agitation followed by solvent casting method [2] and investigating their tensile and antibacterial properties.

2. EXPERIMENTAL PROCEDURE

2.1. PREPARATION OF MgO NANOPARTICLES

The MgO nanoparticles are synthesized by the precipitation method [3]. 20 ml of sodium hydroxide solution (0.2 M, 0.8 gm) is slowly added to magnesium nitrate solution (0.1 M, 2.56 g in 50 ml of water) with vigorous stirring for 2 hours. A white precipitate of $Mg(OH)_2$ is obtained and centrifuged to separate the white precipitate of $Mg(OH)_2$. The process is repeated by washing with water several times to remove the impurities.

$$Mg(NO_3)_2 \cdot 6H_2O + 2NaOH \rightarrow Mg(OH)_2 + NaNO_3$$

$Mg(OH)_2$ in wet form is mixed with 1 gm of cellulose powder and dried at 100 ^{0}C and then calcined at 300 ^{0}C for 2 hour in muffle furnace. During calcination, the decomposition of $Mg(OH)_2$ into MgO takes place. The white powder obtained is cooled and stored in vacuum.

$$Mg(OH)_2 \longrightarrow MgO + H_2O$$

2.2 PREPARATION OF PVA FILM AND MgO-PVA NANOCOMPOSITE FILM

The pure PVA film has been prepared by solvent casting method by dissolving 0.5gm of PVA in 50ml of distilled water with heating at 50 ^{0}C. In the similar method, the polymer nanocomposite film is prepared by incorporating 4% of the synthesized MgO nanoparticles (0.02gm) into the PVA (0.5gm in 50ml of distilled water) suspension and the resulting suspension is sonicated for 20 minutes. This process makes the uniform distribution of MgO nanoparticles in the polymer matrix. The sonication is performed at amplitude of 25 in a probe type sonicator.

3. RESULT AND DISCUSSION

The XRD pattern of the MgO nanoparticles prepared by the precipitation cum combustion method is shown in the Fig.1. The diffraction pattern and interplanar spacing is closely matched with the standard diffraction pattern of MgO [6]. The average crystallite size of the nanoparticles synthesized by the precipitation method is calculated using the Scherer equation and is found to be in the range of 25 nm.

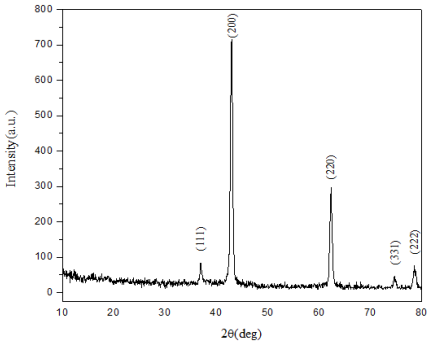

Fig.1 XRD Pattern of MgO nanoparticles.

The XRD pattern of MgO-PVA nanocomposite film (Fig is not shown) show highly intensed peaks due to the presence of inserted MgO nanoparticles in the PVA matrix [7]. The reason is mainly due to the large weight fraction of the amorphous polymer matrix (96%), the amorphous contribution dominated the scattering spectrum, and it was not possible to clearly discern the metal oxide contribution in the overall scattering of the nanocomposite. Therefore, the salient features of the MgO-PVA nanocomposite film is characterized by using the FTIR spectroscopy.

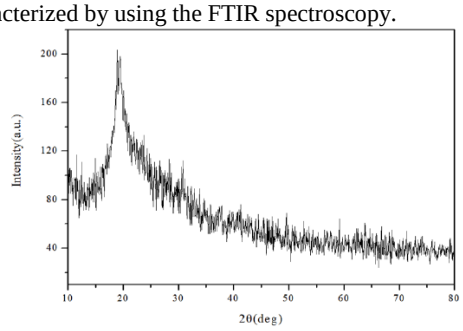

Fig.2 XRD pattern of MgO/PVA nanocomposite film.

The IR spectrum of MgO/PVA nanocomposite film exhibits several bands characteristic of stretching and bending vibrations of O–H, C–H and C–O groups at 1080 cm^{-1}, 916 cm^{-1}, 1317 cm^{-1}, 1740 cm^{-1}, 1619 cm^{-1} respectively [8]. The twin bands at 2923 cm^{-1} and 2853 cm^{-1} represents C-C stretching of PVA. Two strong bands observed at 1429 and 852 cm^{-1} have been attributed to bending and stretching modes of CH_2 group respectively. The bands at 523cm^{-1} and 3273cm^{-1} corresponds to the optical vibration modes of MgO nanoparticles [9]. The sharp peak seen at 523cm^{-1} is associated with the longitudinal optical (LO) phonon mode of MgO lattice. The peak at 3273cm^{-1} corresponds to the hydrogen bonded hydroxyl group of PVA to MgO. All these peaks reveal the existence of MgO nanoparticles in the MgO/ PVA nanocomposite film and firmly attached with the polymer at molecular levels.

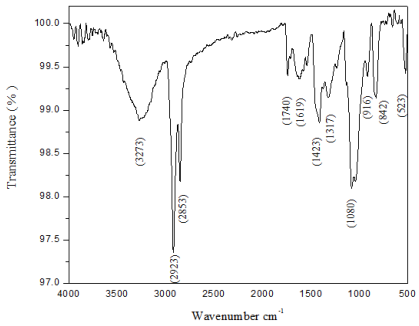

Fig. 2 FTIR of MgO / PVA nanocomposite film.

The surface morphology of the MgO nanoparticle and the polymer nanocomposite film are analyzed by Atomic Force Microscopy and is shown in Fig.4. It shows that the nanoparticles are evenly distributed in the range of 30nm. From Fig.4. (b), it is found that the MgO nanoparticles are dispersed uniformly within the polymer matrix.

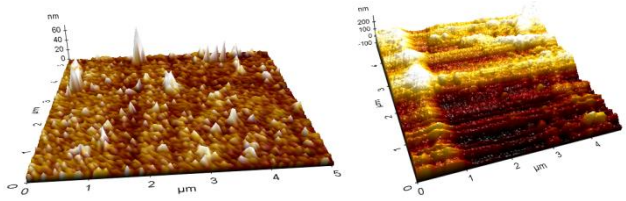

Fig. 3 Surface morphology (a) MgO nanoparticles & (b) MgO/PVA nanocomposite film.

The mechanical properties such as tensile strength and elongation break of the two respective films were measured at 27^0C. The thickness of the pure PVA film and the nanocomposite film were measured and are given as 0.05 mm and 0.06 mm respectively. The elongation @ break and the tensile strength can be calculated using the formulas viz.

$$\text{(i) Elongation @ break \%} = \frac{\text{Extended length at break}}{\text{Original length}} * 100$$

$$\text{(ii) Tensile Strength} = \frac{\text{Maximum load}}{\text{Width} * \text{Thickness}} \text{ MPa}$$

Although both are PVA films with the same chemical structure, it is clearly noticed from the Force / elongation@break studies that the nanocomposite film shows increase in tensile behavior than the pure PVA film. The enhancement of tensile behavior of the polymer nanocomposite film is mainly due to the bonding between the MgO with the PVA matrix. Such reinforcement causes saturation of the residual energies of –OH groups by intramolecular hydrogen bonding which is obviously explained by FTIR studies. For both films, the mechanical properties have been evaluated and represented in Table 2.

Table.2 Mechanical properties of the polymer nanocomposite obtained from the material testing machine.

Mechanical Studies	Pure PVA film	Nanocomposite film
Elongation Break(%)	117.5	169.13
Tensile Strength (MPa)	16.16	32.36

The nanocomposite film shows antibacterial activity due to the photocatalytic activity of MgO nanoparticles present in the nanocomposite film. The antibacterial activity of the nanocomposite film against *E.coli.* was taken by use of spread plate method. The *E.coli.* organism was spread over two petri plates, 0.1ml using a L-rod. 0.1 ml of DMSO is added to the first plate which is used as the control. 0.1ml of extract (nanocomposite film) is added to the second plate and both the films are incubated for 24 h. The result shows that the plate with the extract showed relatively less growth of *E.coli* when compared to the control. The areas of no growth can be identified as clear patches in the second plate which shows that toxicity of the MgO nanoparticle to the *E.Coli.* organism due to its photocatalytic activity. However the author is not evaluating the antibacterial activity of the nanocomposite film with increasing the MgO concentration. And also our future work will focus on estimating the antibacterial activity by increasing the concentration of MgO nanoparticle in the nanocomposite film and hope for better results.

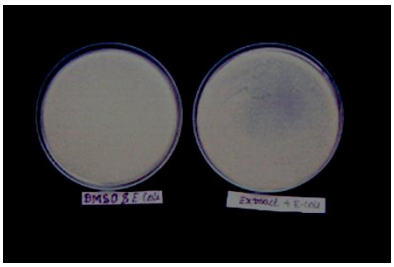

Fig. 4 Antibacterial activity of (a) control (DMSO + *E.coli*) & (b) Extract + *E.coli*

4. CONCLUSION

The MgO nanoparticles of mean particle size 25nm are prepared by combustion method. The sonochemical agitation followed by solvent casting method is used to fabricate MgO-PVA nanocomposite film by incorporating the MgO nanoparticles into the PVA matrix. The FTIR spectroscopy of the nanocomposite film confirms the presence of MgO nanoparticle in the PVA matrix. The surface morphology by AFM of the MgO-PVA nanocomposite film shows that the nanoparticles are dispersed uniformly in the PVA matrix. The study on the tensile behavior shows that the nanocomposite film has higher tensile strength nearly two times compared to the pure PVA film. Moreover, the antibacterial studies show that the organism *E.Coli* is found to be sensitive to the MgO/PVA nanocomposite film.

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