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Optical Properties of Polyvinyl Alcohol Membrane with n-HAp for Bio-Medical Applications

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Abstract

Composite membrane as a flexible materials have found diverse applications in industrial and biomedical simultaneously,the recent studies have shown intrinsic improvement for membrane properties by inclusion of nanoparticles as a fillers with high portion ratio in inorganic polymers, the combination between two parts polymer and filler is as a result of collection the advantage of two component systems parts together. In this work, samples of polyvinyl alcohol (PVA)-nanoHaydroxyapatite (nHAp) composites were prepared by using casting method. The effects of addition of (nHAp) with different concentration on the optical properties of (PVA- nHAp) composite membrane have been studied by using wavelength range (220-820) nm. The absorption spectra, transmittance spectra, absorption coefficient, energy gap, refractive index ,optical conductivity and extinction coefficient have been determined. The results show that the optical constants change with the increase of nHPA concentrations.

Keywords: Polyvinyl Alcohol; Nano Hydroxyapatite; Bio composite; Optical properties; Casting method

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Introduction

Composite membrane as aflexible materials have found varied applications in industrial and biomedical simultaneously, the recent studies have shown essential improvement for membrane properties by inclusion of nanoparticles as afillers with high portion ratio in inorganic polymers [1]. The combination between two parts polymer and filler is as aresult of collection the advantage of two component systems parts together [2], for example flexibility, chemical stability, elasticity, in addition mechanical and thermal stabilities [3].

Poly(vinyl alcohol) PVA, is a water-soluble polymer, it has been selected as an organic part for bio composite. PVA membranes are flexible materials and own, high dimensional stability, high transparency and super permeability properties. PVA has been a known semi-crystalline polymer which possesses certain physical properties due to its crystal-amorphous interfacial effect [4].

An inorganic bioactive essential such as, nHApnano-particles have been purposely compound with hydrogels to offer essential biological and mechanical properties [5]. Hydroxyapatite, HAP or calcium phosphate ($Ca_{10}(PO_4)_6$ $(OH)_2$, has been regularly employed formerly as scaffold or implanting materials in biomedical applications, due to its unique biological action and physicochemical properties [6]. Furthermore, nHAp has superior specific surface area and excellent mechanical and biological properties [7]. Here, the purpose behind incorporation of HAp into PVA matrix allows reducing the glass transition temperature (Tg), the crystallinity degree, and thus increases the amorphous phase of the PVA polymer matrix.

Biomedical composite have been used in many applications including dental, bone and tissue implant, temporary skin cover or burn dressing, drug delivery materials, blend membrane, synthetic cartilage in recon structure joint surgery and artificial organs because it have good properties [8], it is good biocompatibility, carcinogenicity, non-toxityand desirable physical properties such as rubbery and elastic nature, resistant to oil, high degree of swelling in aqueous solutions [9].

The study of this materials have been a key element of bone tissue engineering. The present study is focused toinvestigation the effect of doping different concentration of nHApon the optical properties of the PVAmatrix .

Materials and methods

Synthesis of nHAP powder

nHAp powder was prepared by wet chemical precipitation process by weighing (19.718 gm) of $Ca(NO_3)_2.4H_2O$ and (6.603 gm) of $(NH_4)_2HPO_4$, then dissolving the materials in deionized water separately. The pH of each aqueous solution was adjusted to 11 by using NH_4OH solution. Drop wise addition of $Ca(NO_3)_2.4H_2O$ aqueous solution to vigorously magnetic stirred $(NH_4)_2HPO_4$ solution is achieved at room temperature for about 1h. The resulted mixture is a milky in color and some what gelatinous precipitate ions were occurred at stirred for 1h. The precipitates were washed with distilled waterand then left immersed in distilled water for 24h for ageing then filtered and dried at 100℃ over night using an oven and then crushed to very fine powder.

Preparation of PVA_ nHAPmembrane

Composite films were prepared in this study by using solution casting technique, PVA was dissolved in double distilled water by using magnetic stirrer then nHAp powder was added with ratio are (5,10,15, and 20) wt% and mixed until get homogeneous solutions. Absorption and transmission spectra were record for wavelength 220-820 nm.

Result and Discussion

Scanning Electron Microscopy (SEM) Analysis

Size and morphology of nHAp were studied by Scanning electron microscope, the nanoparticles are spherical in shape, the structure of Nano particles distributed uniformly (Figure 1).

A (UV-210^{0}A shimedza) double beam spectrophotometer with wavelength range (220-820) nm was used to measure the absorption spectra of the samples. The optical absorbance against the wavelength of the light incident for (PVA_nHAp) composites was presented in the figure (Figure 2).

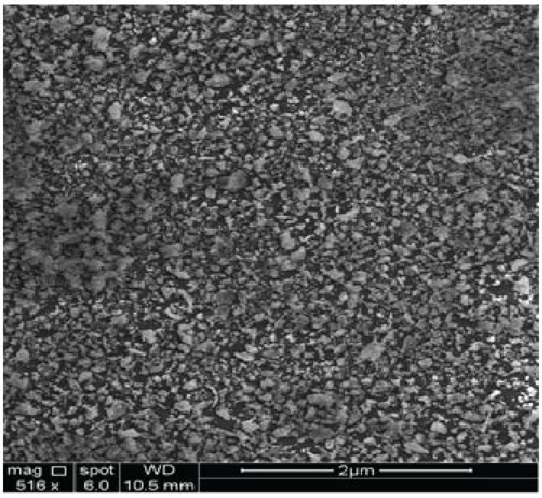

Figure 1: Scanning Electron Microscope (SEM) of nHAp.

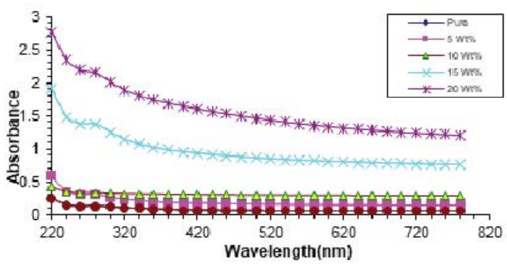

Figure 2: Absorption spectra for PVA-nHAP composite.

As shown in figure the absorbance increases with increase of nHAP concentration and this attributed to high absorbance of nHAp (Figure 2). Absorbance spectrum shows increase in absorption at wavelength near to the absorption edge, the energy corresponding to this region determine the band gap of the composite sample [10], the increasing of nHAp concentration increased absorption edge in the range (220-820) nm of wavelength.

Transmittance spectra was presented in the figure, the optical transitions was increased with wavelength for all samples,the optical transmission for pure PVA was nearly 92% while it decreased to 50% with increasing nHAp concentration to 20%, and this attributed to increase of the absorbance (Figure 3).

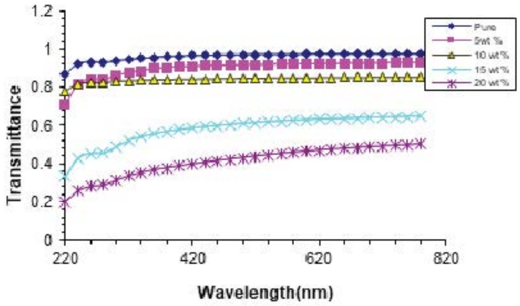

Figure 3: Transmittance spectra for PVA-nHPA composite.

Figure shows the variation of absorption coefficient for (PVA-nHAP) as a function of photon energy, absorption coefficient can calculate from equation (Figure 4) [5].

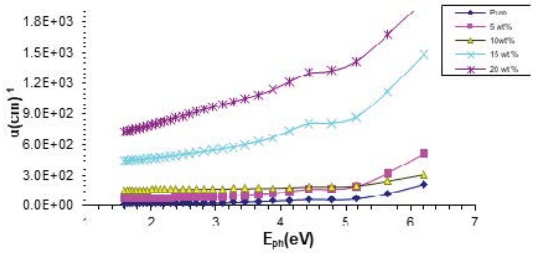

Figure 4: Absorption coefficient for (PVA-nHAP) composite.

$$\alpha = 2.303\,\frac{A}{d}$$

Where A is absorbance and d is the thickness of sample,the values of (α) are less than (10^4 cm^{-1}) (the fundamental of absorption coefficient can be used to determines the nature of the optical band gap E_g, A plot of $(\alpha h\nu)^{1/2}$ versus photon energy as shown in figure 5, the energy band gap of the pure sample was 3.4ev and decreased after increasing the concentration to 3.2ev, 1.2ev and 0.6ev for (5, 10 and 15)wt%, respectively, and reach to 0.2ev for sample with 20wt%.

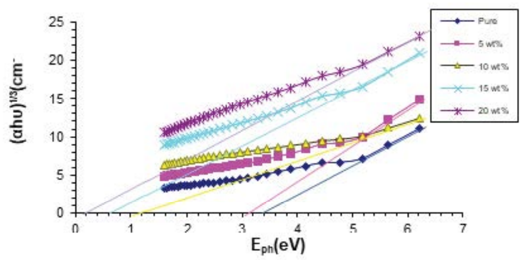

Figure 5: Variation of $(\alpha h\nu)^{1/2}$ versus photon energy for PVA-nHAP composite.

Reflective index and extinction coefficient for (PVA-nHAp) films as a function of wavelength are shown in figures 6 and 7 respectively.

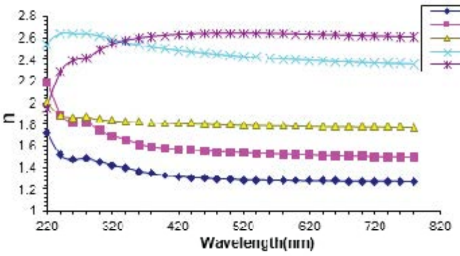

Figure 6: Reflective index versus wavelength of PVA-nHAP composite**.**

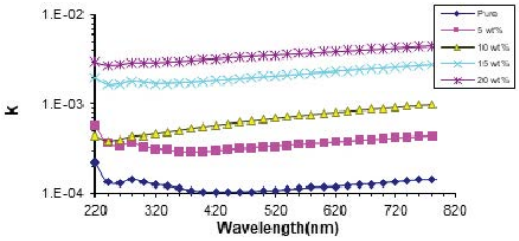

Figure 7: Extinction coefficient versus wavelength of PVA-nHAp composite.

The reflective index for composite decreases with increasing of wavelength while, reflective index closely related to the electronic polarization of ion and local field in side materials from the figure thereflective index increasing with increased of nHAP concentration which is a result of increasing the number of atomic refractions due to increase linear polarizability (Figure 6).

Figure 8 and figure 9 presented the variation of real and imaginary part of dielectric constants $\varepsilon_1= n^2-k_2$ [11] and $E_2=2nk$ [12], ε_1 mainly depends on n^2 because of small values of k^2, ε_2 mainly depend on the (k) values, dielectric constants increases with increasing nHAp concentration andthe parameters are almost constant at higher wavelength.

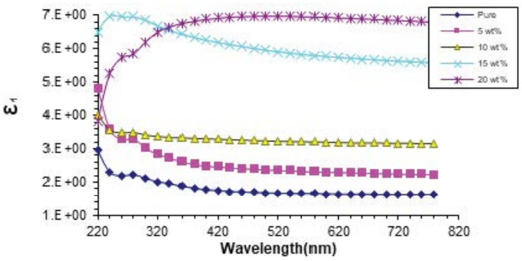

Figure 8: Variation of real part of dielectric constant (PVA-nHAp) composite with photon energy.

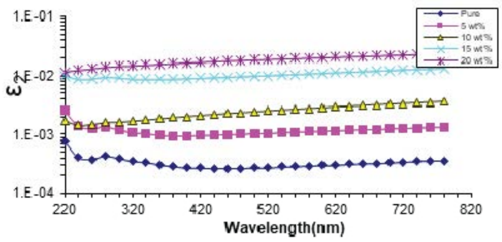

Figure 9: Variation of imaginary part of dielectric constant (PVA-nHAp) composite with photon.

Figure 10 shows the variation of optical conductivity of (PVA-nHAp) composite optical conductivity for all samples increases with increasing of nHAp concentration due to high absorbed of polymer composite films, the increase of optical conductivity and decrease in band gap energy with increase of nHAp concentration can be attributed in the increase in number of mobile charge carriers and also to the increase in amorphous nature of polymer composite.

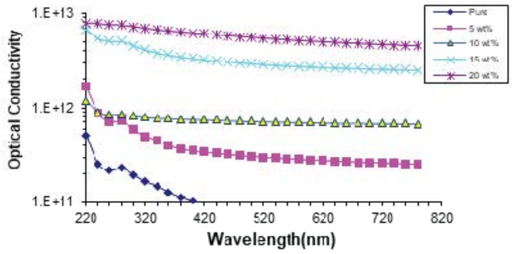

Figure 10: Optical conductivity for PVA-nHAP composite.

Conclusion

This paper illustrate that the optical properties of (PVA-nHAP) enhanced and improved by increasing the concentration of nHAP. The absorbance and optical conductivity was increased with increasing nHAP concentration while the transmittance and the reflective index decreased. The energy band gap of the pure sample was 3.4ev and decreased with increasing the concentration and reach to 0.2ev for 20wt%.

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