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ENHANCEMENT IN SOME PHYSICAL PROPERTIES OF (PVP:CMC) BLEND BY THE ADDITION OF MgO[†]

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This research study explores the effects of adding MgO nanoparticles to a polymeric blend composed of 50% PVP and 50% CMC. The blend was prepared using MgO nanoparticles (0.2%, 4%, and 6%) and varying processing conditions. The structural, optical, and electrical properties of the resulting blend were analyzed to determine the impact of the added nanoparticles on the blend's properties. Results showed that the addition of nanoparticles significantly improved the structural, optical, and electrical properties of the polymeric blend. Specifically, the energy gap is 4.224 eV for (PVA: CMC) film and increased to 3.432 eV for (PVA: CMC-6% MgO), the light transmission and reflection properties were enhanced. Additionally, the conductivity of the blend was increased, making it suitable for various applications, including optoelectronics, sensors, and biomedical devices. Overall, this study demonstrates the potential of adding nanoparticles to polymeric blends to improve their properties and highlights the importance of optimizing processing conditions to achieve the desired properties for specific applications.
Keywords: *PVA; CMC; MgO Nanoparticles; FTIR; SEM; Optical and electrical properties*
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INTRODUCTION

Polyvinylpyrrolidone is a water-soluble polymer made from the monomer vinylpyrrolidone. PVP has a variety of applications due to its unique properties, including its ability to form stable complexes with many different compounds [1], In the context of polymers used in personal care products, PVP is often used as a binder, film-former, and viscosity enhancer in hair styling products such as gels and mousses. It can also be found in skincare products such as moisturizers, which help to improve the texture and spreadability of the product. In addition to its use in personal care products [2,3]. carboxymethyl cellulose is a water-soluble polymer derived from cellulose. CMC is widely used in a variety of industries, including food, pharmaceuticals, and personal care products. In the food industry, CMC is used as a thickener, stabilizer, and emulsifier [4]. It is commonly found in ice cream, baked goods, and sauces. In the pharmaceutical industry, CMC is used as a binder in tablet formulations, and it is also used as an ingredient in eye drops and other topical medications [5,6]. Blending polyvinylpyrrolidone (PVP) and carboxymethyl cellulose (CMC) polymers can result in a material with enhanced properties, such as improved solubility, stability, and film-forming ability. The addition of (MgO) to the blend can further enhance these properties. MgO is an inorganic compound that is commonly used as a pH regulator and as a source of magnesium ions in various applications [7]. When added to a PVP: CMC blend, MgO can act as a crosslinking agent, which improves the mechanical strength and water resistance of the resulting material. The resulting PVP:CMC: MgO blend can have a variety of applications, including as a thickener, binder, and film-forming agent in various industries such as food, pharmaceuticals, and personal care products. For example, it can be used as a thickener in toothpaste or as a binder in tablet formulations [8]. Overall, the addition of MgO to a PVP: CMC polymer blend can result in a material with improved properties, making it more versatile and useful in a variety of applications [9,10]. In this study, we Preparation of the blend will depend on the 50% ratio of PVP, 50% CMC, and adding nanoparticles to the polymeric matrix, 0,2%,4%, and 6% from MgO, The addition of nanoparticles can improve the Structural, Optical, and electrical properties.

EXPERIMENTAL

The solution casting method is a relatively simple and efficient way to prepare PVP: CMC composite films and the addition of MgO can further enhance the properties of the resulting films, Pure and doped with MgO, the PVP: CMC composite films can be prepared by the solution casting method. This method involves dissolving the PVP, and CMC, in a suitable solvent (water) at (60°C), to form a homogenous solution, and adding MgO at different weight ratios of 2, 4, and 6 wt%, The solution is then cast onto a flat surface and allowed to dry, resulting in a thin film.

RESULTS AND DISCUSSIONS

The infrared spectra of (PVP: CMC) can provide information about the chemical composition and structural features of the polymer blend. Here are some of the characteristic peaks that may be observed in Fig. (1) FTIR spectra of (PVP: CMC):

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A peak around 23500 cm^{-1}, corresponds to the -CH stretching vibration of the CMC backbone. A peak around 1650 cm^{-1}, corresponds to the -COO- stretching vibration of the carboxyl group in CMC. A peak around 1420 cm^{-1}, corresponds to the -CH bending vibration of the CMC backbone [11,12]. PVP peaks: A peak around 3400 cm^{-1}, which corresponds to the -NH stretching vibration of the amide group in PVP [13,14]. A peak around 2950 cm^{-1}, corresponds to the -CH stretching vibration of the PVP backbone. A peak around 1550 cm^{-1}, corresponds to the -C=O stretching vibration of the amide group in PVP [15]. In addition, the FTIR spectra of (PVP: CMC) may also show some overlapping peaks, such as the -OH stretching vibration of water molecules, which may be present as a result of the hygroscopic nature of CMC. It is important to note that the specific FTIR spectra of (PVP: CMC) may vary depending on the specific ratio and blending method used. MgO nanoparticles peaks: A peak around 3700-3500 cm^{-1} corresponds to the -OH stretching vibration of surface hydroxyl groups on the MgO nanoparticles [16]. A peak around 1600-1500 cm^{-1}, corresponds to the bending vibration of O-H on the surface of the MgO nanoparticles. A peak around 1400-1300 cm^{-1} [17,18], corresponds to the symmetric stretching vibration of Mg-O bonds in the MgO nanoparticles. In addition, the FTIR spectra of CMC: PVP doped with MgO nanoparticles may also show some overlapping peaks [19,20], such as the -OH stretching vibration of water molecules and the -CH stretching vibration of the CMC and PVP backbones [21]. It is important to note that the specific FTIR spectra of CMC: PVP doped with MgO nanoparticles may vary depending on the specific doping concentration and preparation method used [22].

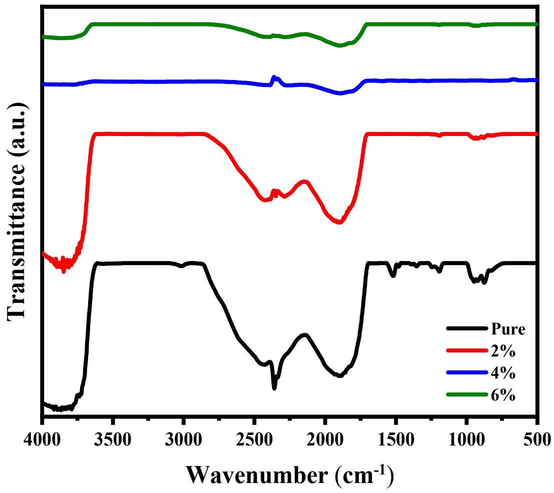

Figure 1. FTIR for PVP: CMC-MgO Nanocomposite

Figure (2) reviews the field-emitting scanning electron microscopy (FE-SEM) images of the prepared films (PVP: CMC) before (a) and after reinforcement with MgO nanopowder in the ratio (b). It shows that the (PVP: CMC) film has a rough surface. From a group of accumulated minutes stacked together

When MgO nanoparticles were added, the images showed that the reinforced polymeric films had irregular and rougher surfaces and high surface porosity compared to the films before cementation, and this is attributed to the hydrogen bonding resulting from the active carboxyl and hydroxyl Functional groups [23,24]. This irregular, rough, and high porosity of the surface enhances the adsorption Chemistry of the prepared overlapping films [25].

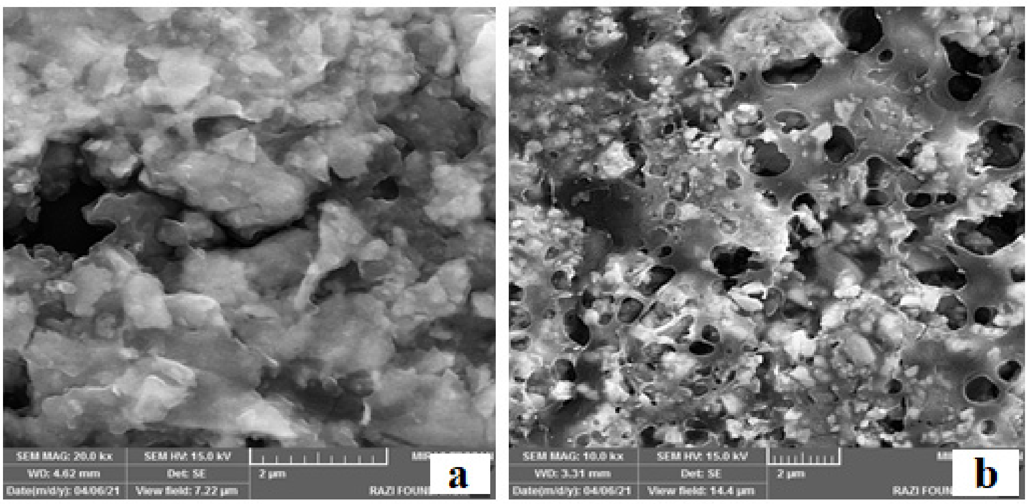

Figure 2. FE-SEM for PVP: CMC-MgO Nanocomposite

The addition of MgO nanoparticles to the (PVP: CMC) blend can have significant effects on both the transmittance and reflectance of the resulting material, The transmittance of (PVP: CMC) doped with MgO nanoparticles can be decreased in the visible and near-infrared regions, The nanoparticles can scatter and absorb light more than the polymer blend, which can result in more light being reflected from the surface of the material [26,27], The effect of MgO nanoparticles on transmittance and reflectance can be dependent on the wavelength of light. Higher concentrations of nanoparticles can result in stronger scattering and absorption [28,29], which can result in more significant changes in transmittance (T%) and reflectance (R) as shown in Fig.(3).

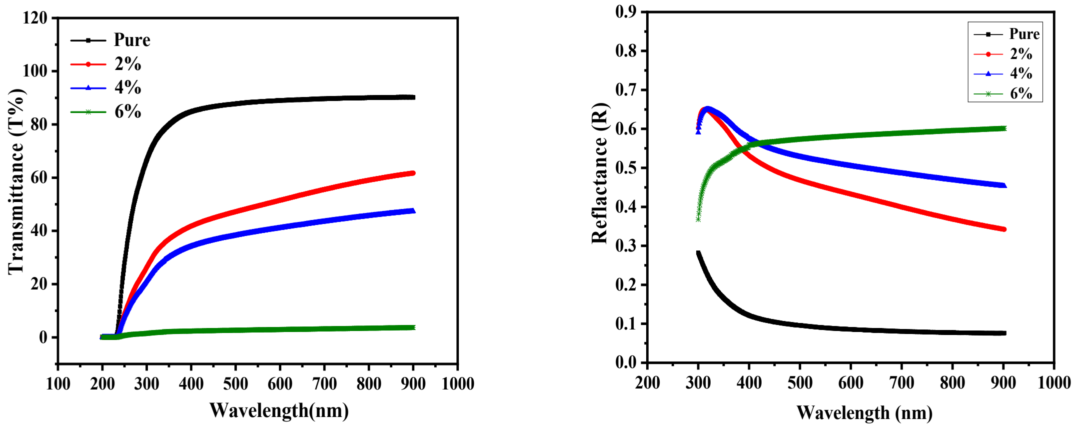

Figure 3. T% and R for PVP: CMC-MgO Nanocomposite

The energy gap of (PVP: CMC) doped with MgO nanoparticles can be decreased due to the additional electronic states introduced by the nanoparticles [30], The decrease in the energy gap can result in increased absorption in the UV-visible region, as shown in Fig. 4. The effect of MgO nanoparticles on the absorption coefficient and energy gap can also depend on the size of the nanoparticles. Smaller nanoparticles can introduce more additional electronic states and result in more significant changes in the energy gap [31], The surface properties of the MgO nanoparticles can also play a role in the effect on the absorption coefficient and energy gap, The presence of surface defects and impurities on the nanoparticles can introduce additional electronic states and result in changes in the optical properties of the resulting material [32]. As in the following equation [33]:

$$\alpha h\upsilon = A(h\upsilon - E_g)^n \quad (1)$$

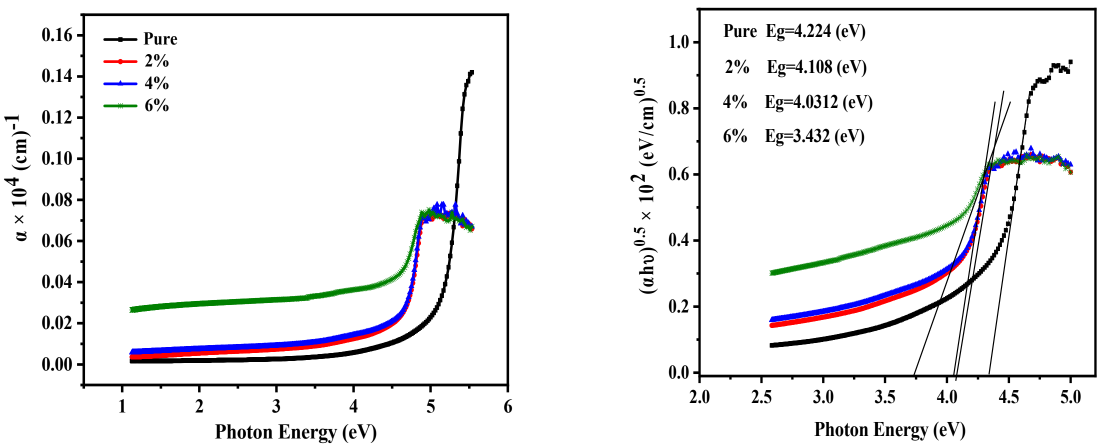

Figure 4. α and Eg for PVP: CMC-MgO Nanocomposite

The extinction coefficient of PVP: CMC doped with MgO nanoparticles can be increased due to the additional absorption features introduced by the nanoparticles, MgO nanoparticles have a higher refractive index than PVP: CMC polymers, so the addition of the nanoparticles can increase the overall refractive index of the material, This can result in increased light bending and potential optical effects such as light confinement, as shown in Fig. (5). The refractive index (n_o) and the extinction coefficient (k_o) can be calculated using the two following equations below [34,35]:

$$n_o = \left[\frac{(1+R)^2}{(1-R)^2} - (k_o^2 - 1)\right]^{\frac{1}{2}} + \frac{(1+R)}{(1-R)} \quad (2)$$

$$k_o = \frac{\alpha\lambda}{4\pi} \quad (3)$$

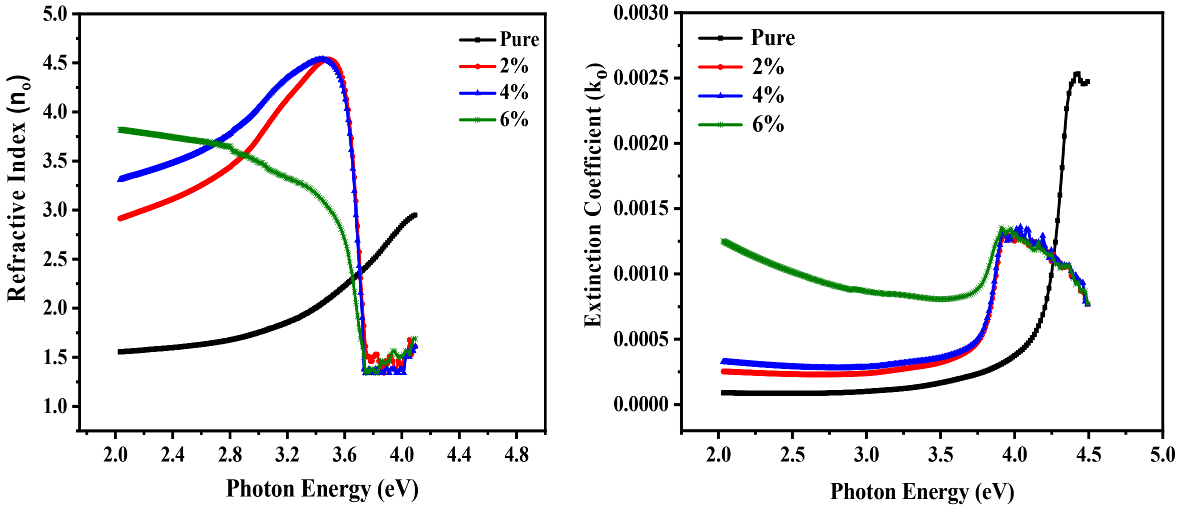

Figure 5. n_o and k_o for PVP: CMC-MgO Nanocomposite

Electrical Characterizations

Dielectric Constant (ε')

The addition of MgO nanoparticles to (PVP: CMC) polymers can increase the dielectric constant of the material due to the presence of additional polarizability from the nanoparticles, The effect of MgO nanoparticles on the dielectric constant of (PVP: CMC) polymers can also depend on the size of the nanoparticles. Smaller nanoparticles can have a greater surface area and more electronic states, which can result in more significant changes in the dielectric constant [36], The dielectric constant of (PVP: CMC) doped with MgO nanoparticles can also depend on the frequency of the applied electric field [37], The dielectric constant of (PVP: CMC) doped with MgO nanoparticles can also depend on the temperature of the material, At high temperatures, the polarizability of the material can change, resulting in a change in the dielectric constant [38], as shown in Fig.(6).

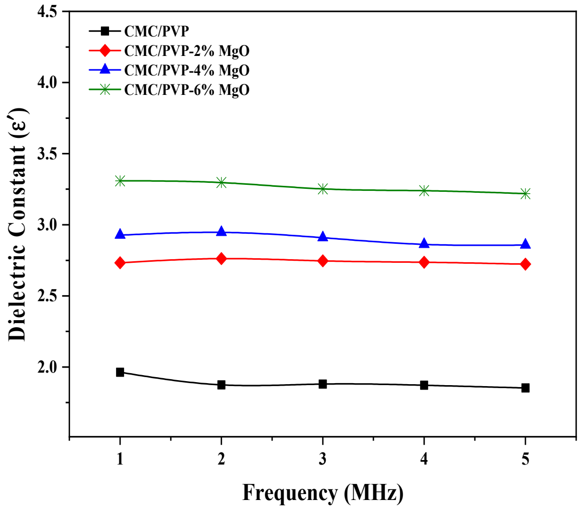

Figure 6. Dielectric Constant for PVP: CMC-MgO Nanocomposite

Dissipation Factor (tanδ)

The addition of MgO nanoparticles to PVP: CMC polymers can decrease the dissipation factor of the material due to the presence of additional polarizability from the nanoparticles, The dissipation factor can decrease with increasing concentration of the nanoparticles, as shown in Fig. 7. The effect of MgO nanoparticles on the dissipation factor of (PVP: CMC) polymers can also depend on the size of the nanoparticles. Smaller nanoparticles can have a greater surface area and more electronic states, which can result in more significant changes in the dissipation factor [39], The dissipation factor of (PVP: CMC) doped with MgO nanoparticles can also depend on the frequency of the applied electric field. The dissipation factor of (PVP: CMC) doped with MgO nanoparticles can also depend on the temperature of the material. At high temperatures, the polarizability of the material can change, resulting in a change in the dissipation factor, the effect of MgO nanoparticles on the dissipation factor of (PVP: CMC) polymers can depend on various factors such as nanoparticle size, concentration, temperature, and frequency. The resulting electrical properties can have potential applications in areas such as capacitors, sensors, and electronic devices [40].

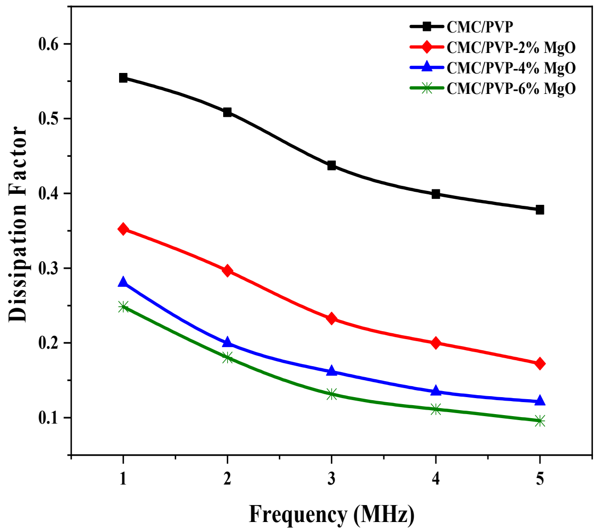

Figure 7. Dissipation Factor for PVP: CMC-MgO Nanocomposite.

A.C. Electrical Conductivity ($\sigma_{a.c}$)

The addition of MgO nanoparticles to (PVP: CMC) polymers can increase the electrical conductivity of the material due to the presence of additional free charge carriers, The effect of MgO nanoparticles on the electrical conductivity of (PVP: CMC) polymers can also depend on the size of the nanoparticles [41], The electrical conductivity of PVP: CMC doped with MgO nanoparticles can also depend on the frequency of the applied A.C. electric field. The conductivity can increase or decrease depending on the frequency range [42], as shown in Fig. (8).

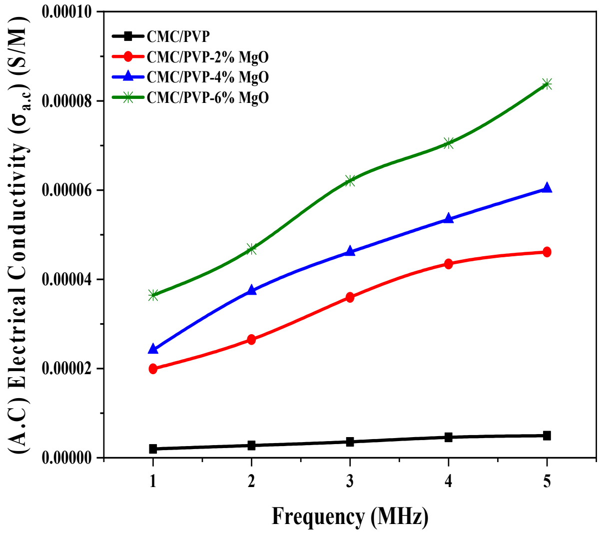

Figure 8. AC electrical conductivity for PVP: CMC-MgO Nanocomposite

CONCLUSIONS

The addition of MgO nanoparticles (0.2%, 4%, and 6%) to the 50% PVP, and 50% CMC can enhance the structural properties by improving the mechanical strength, thermal stability, and surface morphology by casting method. Additionally, the optical properties of the blend can be enhanced, leading to better light transmission and reflection properties. The energy gap is 4.224 eV for (PVA: CMC) film and when the MgO concentration at 6% is increased to 3.432 eV. the electrical properties can be improved by increasing the conductivity of the (PVA/CMC) blend. Therefore, the use of nanoparticles in the preparation of polymeric blends has significant potential for improving their properties, making them suitable for various applications such as optoelectronics, sensors, and biomedical devices. Further studies can be carried out to optimize the concentration and size of the nanoparticles, as well as the processing conditions, to achieve the desired properties for specific applications.

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ПОКРАЩЕННЯ ДЕЯКИХ ФІЗИЧНИХ ВЛАСТИВОСТЕЙ СУМІШІ (PVP:CMC) ШЛЯХОМ ДОДАВАННЯ MgO

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Досліджено вплив додавання наночастинок MgO до полімерної суміші, що складається з 50% PVP і 50% CMC. Суміш готували з використанням наночастинок MgO (0,2%, 4% і 6%) і різних умов обробки., Для визначення впливу доданих наночастинок були проаналізовані структурні, оптичні та електричні властивості отриманої суміші. Результати показали, що додавання наночастинок значно покращило структурні, оптичні та електричні властивості полімерної суміші. Зокрема, енергетичний зазор становить 4,224 еВ для плівки (PVA:CMC) і збільшено до 3,432 еВ для (PVA:CMC-6% MgO). Також були покращені властивості пропускання світла та відбивання. Крім того, провідність суміші була збільшена, що зробило її придатною для різних застосувань, включаючи оптоелектроніку, датчики та біомедичні пристрої. Загалом це дослідження демонструє потенціал додавання наночастинок до полімерних сумішей для покращення їхніх властивостей і підкреслює важливість оптимізації умов обробки для досягнення бажаних властивостей для конкретних застосувань.

Ключові слова: *PVA; CMC; наночастинки MgO; FTIR; SEM; оптичні та електричні властивості*