Enhancing the Optical Properties of Chitosan, Carboxymethyl Cellulose, Sodium Alginate Modified with Nano Metal Oxide and Graphene Oxide

Amina Omar

Ain Shams University Faculty of Science

Rania Badry

Ain Shams University Girls' College for Arts Science and Education: Ain Shams University Faculty of Women for Arts Science and Education

Maroof A. Hegazy

NRIAG: National Research Institute of Astronomy and Geophysics

Ibrahim S. Yahia

King khaled University

Hanan Elhaes

Ain Shams University Womens College for Arts Science and Education: Ain Shams University Faculty of Women for Arts Science and Education

Heba Y. Zahran

King Khaled University

Medhat IBRAHIM (✉ medahmed6@yahoo.com)

NRC, Egypt

Ahmed Refaat

SESSAME

Research Article

Keywords: Chitosan, CMC, Sodium alginate, TiO₂, Graphene oxide, Optical properties

Posted Date: January 12th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1079643/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

The solution casting method was utilized to synthesize nanocomposite films of chitosan (Cs)/CuO, Cs/graphene oxide (GO), carboxymethyl cellulose (CMC)/TiO₂, CMC/GO, sodium alginate (Na Alg)/TiO₂, and Na-Alg/GO owing to their various applications. The influence of CuO, TiO₂ and GO concentration on the optical properties of Cs, CMC and Na-Alg films was studied by UV-Vis Spectroscopy. The absorbance of Cs, CMC and Na-Alg increased with increasing the filler content, thus reflecting the dependence of Cs, CMC, and Na-Alg properties on the nanofiller content, and confirming the interactions between individual polymers and CuO, TiO₂ and GO nanoparticles. The obtained absorbance values were then used to calculate the absorption coefficient and, hence, the optical band gap values. The characteristic absorption bands of CuO and TiO₂ underwent a redshift by increasing the filler content. The results showed that the optical band gap of Cs, CMC, and Na-Alg decreased with filler content, and they possessed 1, 2 and 2 band gaps respectively. The obtained results recommended that Cs, CMC, and Na-Alg nanocomposites can be used in optoelectronic devices.

1. Introduction

The need to fabricate new safe materials is growing due to steady increase in environmental pollution. Therefore, the development of new environmentally friendly materials has become popular (Guido K. et al. 2003; Xu T. 2005; Vilela C et al. 2018). Using natural composite materials, not only means utilizing environmentally friendly and safe materials, but also allowing the best use of the characteristics of the raw materials by compensating for defects in individual parts and increasing its practical value. The negative influences of utilizing plastic bags, for example, can be diminished by utilizing composite materials in food packaging (Kunz D. A. 2013; Qiu J. et al. and Tang Y. et al. 2016).

Careful selection of the raw materials makes it possible to produce composite films with specific characteristics such as biodegradability and antibacterial properties, which is effective for almost all applications (Tharanathan R. N. 2003; Li F. et al. 2015). Over the past few decades, there has been a growing interest in the invention and development of metal ion-polysaccharide complexes to be used in many popular applications such as metal collection, water purification, formation of new catalysts, and many other industrial applications (Khalil K. D. et al. 2020).

Chitosan (Cs), a cationic polysaccharide composed of (1,4) linked 2-aminodeoxy-βD-glucans, is the deacetylated form of chitin. Cs is characterized by its antibacterial activity, non-toxicity, biocompatibility, biodegradability, antioxidant activity, and film-forming ability. The protonable amino group present along the D-glucosamine residues of Cs plays a key role in explaining most of its favorable properties especially in the field of biomaterials such as mucoadhesion, haemostatic activity, permeation-enhancing property, and analgesic effect (Croisier F. and Jérôme C. 2013). Cs films are selectively permeable to sense toxic gases such as CO₂ and CO (Othan S.H. 2019; Xu D. et al. 2021). Hussein E. M. et al. 2021 prepared nanocomposite films based on Cs and titanium dioxide (TiO₂) nanoparticles utilizing the solution casting method.

Cellulose and its derivatives such as cellulose acetate and carboxymethyl cellulose have a wide range of applications including food packaging, thickener, plasticizer, pharmaceuticals, cosmetics, and optoelectronic devices. Carboxymethyl cellulose (CMC) is a plant-derived cellulose derivative, a polyanionic polymer and a water-soluble polysaccharide (Yu J. et al. 2021). CMC possesses low conductivity and must be salt doped to increase its conductivity for use in energy storage devices. El-Naggar M.E. et al. 2021 fabricated a nanocomposite membrane material based on silicon oxide nanoparticles and poly(3,4-ethylene dioxythiophene) incorporated into cellulose acetate matrix. Ezzat D. et al. 2021 studied the dielectric properties of cellulose acetate-molybdenum trioxide nanocomposites. Badry R. et al 2020 studied the electronic properties of CMC blended with polyethylene oxide and acetic acid theoretically.

Sodium alginate (Na-Alg) is a natural polysaccharide extracted from brown algae. From a molecular point of view, Na-Alg is a linear, water-soluble, biodegradable, and biocompatible polysaccharide composed of (1-4) linked β -D mannuronate (M) and α -L guluronate (G) units. The presence of carboxyl A group in the Na-Alg structure provides electronegative properties to other polymers in aqueous solution (Essifi K. et al. and Zhao X. 2021). As Na-Alg is biocompatible, biodegradable, and non-toxic, with its ability to undergo facile synthesis of fine particles, as well as its gelling properties when cross-linked with divalent ions such as calcium and iron cations, it is widely applied in food and pharmaceutical industries (Zhao X. et al and Yang Y. 2021; Berraaouan D. et al 2017).

Transition metal oxides are the most interesting semiconductors because they can be applied to storage devices, electronics, and catalysis (Rashad M. 2020; El-Shamy A. G. et al. 2017). Incorporation of metal oxide nanoparticles into polar polymers alters many properties of the polymer. In addition, they can also be utilized for electronics, optics, and catalysis (Jamróz E. 2019; Taghizadeh S. M. 2020; Badry R. 2021-c)

Cs, CMC, and Na-Alg were selected for this study because of their favorable properties and capability of forming membranes. In this study, copper oxide (CuO), TiO₂ and graphene oxide (GO) were infused into the natural polymer matrix as dopants for enhancing the optical properties of Cs, CMC, and Na-Alg. Ultraviolet-visible (UV-Vis) spectroscopy has been utilized to report the influence of dopants on the optical properties of the polymers. Therefore, the major purpose of this work is to develop active films based on a mixture of natural polymer, and metal oxides and graphene oxide nanoparticles.

2. Materials And Methods

2.1. Materials

Cs with a medium molecular weight was purchased from Sigma Aldrich. CMC with 2.5×10^5 g/mol molecular weight was purchased from K. Patel Chemo-pharma PVT, India. Na-Alg was purchased from Qualikems company, India. Sodium hydroxide (NaOH) ($\geq 97\%$), potassium permanganate (KMnO₄) (99%), phosphoric acid (85%), and graphite powder were purchased from Fisher Chemical. Hydrogen

peroxide (H_2O_2) (30%) was purchased from Piochem and sulfuric acid (96%) was acquired from Scharlau.

2.2. ZnO Nanoparticles preparation

ZnO nanoparticles (ZnO-NP) were produced using the coprecipitation method. A solution of 1M zinc acetate dihydrate in 100 ml deionized water was prepared at 70°C. 2M NaOH was dissolved in 100 ml of deionized water. NaOH was then added dropwise to the zinc acetate solution with strong stirring for 1 hr. The white precipitate was separated by centrifugation at 1000 rpm and washing with deionized water three times. The resulting precipitate was dried overnight in a dryer at 80°C and calcinated at 500°C for 2 hrs.

2.3. GO preparation

GO nanoparticles were synthesized using Hummer's method. H_2SO_4 and H_3PO_4 were mixed in a beaker in a 9:1 ratio. In another beaker, a mixture of 6 g KMnO_4 and 1 g graphite powder was prepared in an ice bath. The two solutions were then mixed and stirred at 50°C for 12 hrs. After cooling the mixture, it was poured into 1 ml of ice containing 30% H_2O_2 . The precipitate was collected by centrifugation at 10,000 rpm, first washed with 200 ml of 30% HCl, then washed several times with deionized water, and finally dried overnight in a room temperature vacuum oven.

2.4. Chitosan/ZnO nanocomposite preparation

0.5 g of Cs was dissolved in 50 ml of deionized water under vigorous stirring at 60°C for 1 hr until Cs was completely dissolved and a viscous solution was obtained. CuO nanoparticles were added to Cs solution with different weight percentages (2, 4, 6 and 8 wt%) as tabulated in Table 1. The Cs/CuO solution was stirred for 2 hrs until CuO nanoparticles were dispersed completely. The solution was cast in plastic petri dishes and left to dry in air for 5 days at 40 °C.

Table 1
Composition of Cs/CuO nanocomposite films

Sample	Cs (g)	CuO (g)	GO (g)
C1	0.50	0.00	0.00
C2	0.49	0.01	0.00
C3	0.48	0.02	0.00
C4	0.47	0.03	0.00
C5	0.46	0.04	0.00
C6	0.49	0.00	0.01

2.5. CMC/ TiO_2 nanocomposite preparation

0.5 g of CMC was dissolved in 50 ml of deionized water under vigorous stirring at 50 °C for 1 hr until CMC was completely dissolved and a viscous solution was obtained. TiO₂ nanoparticles were added to CMC solution with different weight percentages (2, 4, 6 and 8 wt%) as presented in Table 2. The CMC/TiO₂ solution was stirred for 1 hr, then the solution was sonicated for 1 hr for more dispersion of TiO₂ nanoparticles. The solution was cast in plastic petri dishes and left to dry in air for 5 days.

Table 2
Composition of CMC/TiO₂ nanocomposites

Sample	CMC (g)	TiO ₂ (g)	GO(g)
C1	0.50	0.00	0.00
C2	0.49	0.01	0.00
C3	0.48	0.02	0.00
C4	0.47	0.03	0.00
C5	0.46	0.04	0.00
C6	0.49	0.00	0.01

2.6. Na-Alg /TiO₂ nanocomposite preparation

Na-Alg solution was prepared by dissolving 0.5 g of Na-Alg in 50 ml of deionized water and stirred vigorously for 1 hr at 50 °C. After a clear viscous solution of Na-Alg is obtained, TiO₂ nanoparticles was added with different concentrations (2, 4, 6 and 8 wt%). Table 3 shows the different compositions of Na-Alg/ TiO₂ films. The last solutions of Na-Alg/TiO₂ were stirred additionally for 1 hr. To achieve a complete dispersion of TiO₂ nanoparticles, the solutions were sonicated for additionally 30 min at 60 °C. The resulting solutions were then cast in plastic petri dishes and left to dry in air for 5 days.

Table 3
Composition of Na-Alg/TiO₂ nanocomposites

Sample	Na-Alg (g)	TiO ₂ (g)	GO (g)
N1	0.50	0.00	0.00
N2	0.49	0.01	0.00
N3	0.48	0.02	0.00
N4	0.47	0.03	0.00
N5	0.46	0.04	0.00
N6	0.49	0.00	0.01

3. Characterizing Techniques

3.1. UV-vis. measurement

UV-Vis spectra for all polymer nanocomposites were collected at room temperature in the wavelength range of 200–1000 nm, using a Jasco V-630 (Japan) spectrophotometer at Spectroscopy Department, National Research Centre, Cairo, Egypt.

4. Results And Discussion

4.1. UV-vis. absorption results

Determination of the optical characteristics of polymers and metal oxides is of a great interest to investigate their different applications. Fig. 1 shows the absorbance spectra of pure Cs, Cs/CuO films and Cs/GO film versus wavelength collected in the optical range from 200 to 1000 nm. In certain cases, the absorption spectrum measurements of CuO nanoparticles produce an optimum absorption band at 242 nm and another band in the range of 400-600 nm (Rashad, M. et al. 2013) as illustrated in Fig. 1. There is another band at nearly 670 nm and its intensity increased with increasing CuO content. As presented in the figure, the characteristic absorption band of Cs appeared at nearly 214 nm which is attributed to the $n-\pi^*$ and $\pi-\pi^*$ transition of C=C and C=O, and refers to the presence of acetate group residuals. The absorption shoulder beyond 300 nm is attributed to the CuO nanoparticles.

The absorption spectra of CMC, CMC/TiO₂ nanocomposite films that contains different amounts of TiO₂ (2, 4, 6 and 8 wt%), and CMC/GO film, recorded in the range of 200-800 nm, are displayed in Fig. 2. As displayed in the figure, the absorbance of pristine CMC was strongly influenced by the addition of TiO₂ and GO separately. As the CMC absorption edge undergoes a shift towards the higher wavelength region, the figure shows that the intensity of absorption increases with increasing TiO₂ content in the samples which refers to the strong complexation between CMC, and TiO₂ and GO separately. The characteristic absorption band of TiO₂ nanoparticles undergoes a slight blue shift with decreasing the CMC content in the prepared nanocomposites. The characteristic absorption band observed at 207 nm was ascribed to $n-\pi^*$ transitions and that at 345 nm was attributed to $\pi-\pi^*$ which is characteristic for the TiO₂ nanoparticles, and similarly for CMC/GO film (Ali H. E. et al. 2015; Alsulami Q. A. and Rajeh A. 2021). This means that the CMC/TiO₂ nanocomposites have lower particle size.

Figure 3 shows the UV-Vis absorption spectra of pure Na-Alg, and Na-Alg/TiO₂ and Na-Alg/GO nanocomposites. The characteristic absorption peak of TiO₂ nanoparticles is clearly obvious in the Na-Alg/TiO₂ nanocomposites absorption spectra. The redshift of the absorption peaks from 346 to 360 nm can be attributed to the particle size variation during the reaction. Size and morphology of the prepared nanoparticles control the electronic properties of the nanocomposites (Farea M. O. et al. 2020; Flores-Hernández C. G. et al. 2021). At low concentrations of TiO₂, very broad absorption peak is observed with

very low intensity which shows that the number of particles is small with larger particle size. As the concentration increases, the absorption peak becomes narrower with increment in the intensity together with a redshift in the wavelength, indicating that larger particles are formed.

4.2. Optical bandgap results

The optical absorption of polymer nanocomposites is the most important parameter through which the understanding of the band structure of all solids becomes possible. The Beer–Lambert law can be utilized to determine the absorption coefficient (α) of the prepared nanocomposites. The absorption coefficient can be determined directly using the following equation:

$$\alpha = (2.303 \cdot A)/d \quad (1)$$

Where, A is the absorbance and d is the sample thickness. It is known that the optical bandgap of the different materials can be determined from the electron transition between valance and conduction bands (the fundamental absorption). As reported by Tauc and Davis - Mott, the bandgap values, and the type of electron transition between the valence and conduction bands can be determined using the following equation:

$$(\alpha h\nu)^r = B(h\nu - E_g) \quad (2)$$

Where $h\nu$ is the energy of the incident photons, B is a constant and r is a constant that depends on the type of transition. The constant r takes values of 2, 1/2, 2/3 and 1/3 for direct allowed, direct forbidden, indirect allowed or indirect forbidden transition respectively (Badry R. et al. 2021-a and b).

Based on previous work (Kocyigit A. et al. 2020) the type of electronic transition in Cs is direct allowed transition. The direct bandgap energy of pristine Cs, Cs/CuO nanocomposites and Cs/GO nanocomposites is plotted as a function of photon energy in Fig. 4- a, b, and c respectively. Based on the intercept of the linear part of the curves with the photon energy axis, the values of the direct bandgaps were calculated from the last three figures and recorded in Table 4.

From the figure, the direct bandgap energy value of pure Cs is determined and is equal to 2.66 eV, while those of Cs/CuO nanocomposites, as tabulated in Table 4, are 1.66, 1.73, 1.62 and 1.47 eV for 2, 4, 6 and 8 wt% respectively. On the other hand, for Cs/GO nanocomposites, two absorption shoulders were observed corresponding to two bandgaps. The direct allowed bandgaps of Cs/GO film were estimated as 1.22 and 5.68 eV. The reduction of the Cs bandgap can be attributed to the formation of chemical bonds between Cs and CuO nanoparticles that causes the localized states to generate energy between the bands of the highest occupied molecular orbital and the lowest unoccupied one, thus making the lower transitions feasible (Harun M.H. et al. 2009). Therefore, decreasing the direct allowed optical bandgap of pure Cs was achieved with the incorporation of CuO and GO. This result reflects that with increasing CuO content, the direct allowed energy bandgaps decrease in the Cs matrix by increasing the conjugation between Cs unsaturated bonds and CuO nanoparticles, aiming to reduce the energy bandgap. Previous

work confirmed that organic polymers and their nanocomposites with reasonable optical bandgaps are imperative for photonics, and optoelectronic applications. It can then be concluded that Cs/CuO and Cs/GO nanocomposites can be used in optoelectronic devices.

Table 4
Direct allowed bandgap energy values for pure Cs and Cs substituted with 2, 4, 6 and 8 wt% CuO, and 2 wt% GO at room temperature.

Sample	Eg ₁ (eV)	Eg ₂ (eV)
C1	2.66	-
C2	1.66	-
C3	1.73	-
C4	1.62	-
C5	1.47	-
C6	1.22	5.68

Regarding the CMC/TiO₂ nanocomposite films, it was found that CMC has more than one direct bandgap due to its amorphousity, as presented in Figure 5, which are equal to 3.93 and 5.04 eV. Table 5 presents the different values of the optical bandgap for pristine CMC, CMC/TiO₂ and CMC/GO. Figure 5 demonstrates that the addition of different weight percentages of TiO₂ (2, 4, 6 and 8 wt%) to CMC reduces the optical bandgap of CMC. Based on the obtained results, it was found that all the prepared samples have two direct bandgaps and one indirect bandgap due to the formation of localized states within the valence band of CMC (Elkomy G. M. et al. 2016). For CMC/TiO₂ samples, the first bandgap initially decreased until reaching 2.11 eV and then increased again. The reason for this decrease in the bandgap may be attributed to the decrease in the particle size due to the quantum effects. However, increasing the direct optical bandgap beyond 6 wt% of TiO₂ refers to the formation of ion clusters which decreases the mobility, hence increasing the bandgap. These values are determined as presented in Figures 5 and 6. Therefore, it can be concluded that the sample containing 6 wt% TiO₂ is the preferred one as it has the lowest bandgap energy. On the other hand, for CMC/GO nanocomposite film, the first bandgap of CMC decreased to 2.04 eV. This decrease in the CMC optical bandgap is attributed to the presence of a new energy levels within the optical bandgap, which facilitates the electrons movement from the valence band to these localized states within the conduction band, consequently increasing conductivity and decreasing the optical bandgap (Murri R., et al. 1992). However, the second bandgap corresponding to the second absorption edge in the low wavelength region changes irregularly due to the addition of TiO₂ and GO to CMC.

Table 5
Direct (Ed_{g1} and Ed_{g2}) and indirect (Ei_g) optical bandgap of pure CMC, CMC substituted with 2, 4, 6 and 8 wt% TiO_2 and 2 wt% GO

Sample	Ed_{g1} (eV)	Ed_{g2} (eV)	Ei_g (eV)
C1	3.93	5.04	4.66
C2	2.50	5.11	4.24
C3	2.30	5.34	4.33
C4	2.11	4.91	3.05
C5	2.55	4.76	1.86
C6	2.04	3.31	-

Figure 7 shows the plot of $(\alpha h\nu)^2$ versus the photon energy ($h\nu$) for pure Na-Alg, Na-Alg/ TiO_2 and Na-Alg/GO film. It is established that, for direct optical bandgap materials, the valence band top and the conduction band bottom have the same zero k-vector. All of the prepared samples possess two optical bandgaps; the onset bandgap equals 3.90 eV and the HOMO/LUMO gap equal 5.57 eV for pure Na-Alg. It is critical to show that the optical bandgap decreased from 3.90 eV for pure Na-Alg to 2.21 eV for Na-Alg doped with 6 wt% of TiO_2 nanoparticles. Additionally, the HOMO/LUMO bandgap of pure Na-Alg (second bandgap) was decreased to 3.57 eV corresponding to 6 wt% of TiO_2 . However, the optical bandgap for all samples is still smaller than that for pure Na-Alg. Additionally, Na-Alg/GO nanocomposites have two optical bandgaps. However, the onset bandgap decreased strongly with the addition of GO when compared with that of both pure Na-Alg and Na-Alg/ TiO_2 samples. The small optical bandgap of the Na-Alg/ TiO_2 and Na-Alg/GO nanocomposites confirms its suitability for optoelectronics, photonics, and solar cell applications (Murri R., et al. 1992; Elkomy G. M. et al. 2016)

Table 6
Optical direct bandgap for pure Na-Alg and Na-Alg substituted with 2, 4, 6 and 8 wt% TiO₂, and 2 wt% GO nanocomposite films

Sample	E _{g1} (eV)	E _{g2} (eV)
N1	3.90	5.57
N2	2.31	5.42
N3	2.44	5.08
N4	2.21	3.57
N5	2.21	3.61
N6	2.10	5.52

5 Conclusion

The traditional casting method was utilized to prepare Cs/CuO, Cs/GO, CMC/TiO₂, CMC/GO, Na-Alg/TiO₂ and Na-Alg/GO nanocomposite films by incorporating CuO, TiO₂ and GO nanoparticles within the polymer matrix. The optical properties of the synthesized nanocomposite films were investigated. The absorbance of Cs/CuO, Cs/GO, CMC/TiO₂, CMC/GO, Na-Alg/TiO₂ and Na-Alg/GO films were increased and the UV protection for Cs, CMC and Na-Alg was improved upon the addition of nanoparticles. Furthermore, the prepared nanocomposites of Cs/CuO, Cs/GO, CMC/TiO₂, CMC/GO, Na-Alg/TiO₂ and Na-Alg/GO can be utilized in many optical applications since the energy bandgap value is reduced due to the incorporation of different nanoparticles, with increase in the wavelength of the electronic transmission. The obtained results of the current study indicated that Cs, CMC, and Na-Alg nanocomposite films can be utilized as a new membrane material in optoelectronic devices, solar cells, and capacitors.

Declarations

Acknowledgements

The authors extend their appreciation to the Scientific Research Deanship at King Khalid University and the Ministry of Education in KSA for funding this research work through the project number IFP-KKU-2020/10.

References

1. Ali, H. E., Atta, A., Senna, M. M.: Physico-chemical properties of carboxymethyl cellulose (CMC)/nanosized titanium oxide (TiO₂) gamma irradiated composite. Arab J. Nucl. Sci. Appl. **48**(4), 44-52 (2015)

2. Alsulami, Q. A., Rajeh, A.: Synthesis of the SWCNTs/TiO₂ nanostructure and its effect study on the thermal, optical, and conductivity properties of the CMC/PEO blend. *Results Phys.* **28**, 104675 (2021).
3. Badry, R., Elhaes, H., Nada, N., Ibrahim, M.: Study of the Electronic Properties of Solid Polymer Electrolytes Based on Blends of CMC, PEO, and Acetic Acid. *Biointerface Res. Appl. Chem.* **11**, 11009-11002 (2021)
4. Badry, R., El-Khodary, S., Elhaes, H., Nada, N., Ibrahim, M.: Optical, conductivity and dielectric properties of plasticized solid polymer electrolytes based on blends of sodium carboxymethyl cellulose and polyethylene oxide. *Opt. Quantum Electron.* **53**(1), 1-15 (2021)
5. Badry, R., Ezzat, H. A., El-Khodary, S., Morsy, M., Elhaes, H., Nada, N., Ibrahim, M.: Spectroscopic and thermal analyses for the effect of acetic acid on the plasticized sodium carboxymethyl cellulose. *J. Mole Struct.* **1224**, 129013 (2021)
6. Badry, R., Fahmy, A., Ibrahim, A., Elhaes, H., Ibrahim, M.: Application of polyvinyl alcohol/polypropylene/zinc oxide nanocomposites as sensor: modeling approach. *Opt. Quantum Electron.* **53**(1), 1-12 (2021)
7. Berraaouan, D., Elmiz, M., Salhi, S., Tahani, A.: Effect of calcium chloride on rheological behavior of sodium alginate. *Adv. Mater. Proc.* **2**, 629-633 (2017)
8. Croisier, F., Jérôme, C.: Chitosan-based biomaterials for tissue engineering. *Eur. Polym. J.* **49**(4), 780-792 (2013)
9. Elkomy, G. M., Mousa, S. M., Mostafa, H. A.: Structural and optical properties of pure PVA/PPY and cobalt chloride doped PVA/PPY films. *Arab. J. Chem.* **9**, S1786-S1792 (2016)
10. Elkomy, G. M., Mousa, S. M., Mostafa, H. A.: Structural and optical properties of pure PVA/PPY and cobalt chloride doped PVA/PPY films. *Arab. J. Chem.* **9**, S1786-S1792 (2016)
11. El-Naggar, M. E., Abdel-Karim, A., Radwan, E. K., Sharmoukh, W., Wassel, A. R., Bayoumy, A. M., Ibrahim, M.: Experimental and theoretical investigations on fouling resistant cellulose acetate/SiO₂ NPs/PEDOT ultrafiltration nanocomposite membranes. *J. Clean. Prod.* 129288 (2021)
12. El-Shamy, A. G., Attia, W. M., Abd El Kader, K. M.: Enhancement of the conductivity and dielectric properties of PVA/Ag nanocomposite films using γ irradiation. *Mater. Chem. Phys.* **191**, 225-229 (2017)
13. Essifi, K., Brahmi, M., Berraaouan, D., Ed-Daoui, A., El Bachiri, A., Fauconnier, M. L., Tahani, A. Influence of Sodium Alginate Concentration on Microcapsules Properties Foreseeing the Protection and Controlled Release of Bioactive Substances. *J. Chem.* **2021**(2021)
14. Ezzat, D., Youssif, M., Elhaes, H., El-Nahass, M.: ICMMS-2: Dielectric Relaxation Behaviour and AC Electrical Conductivity of Cellulose Acetate-Molybdenum Trioxide Nanoparticle Blended Film. *Egypt. J. Chem.* **64**(3), 5-7 (2021)
15. Farea, M. O., Abdelghany, A. M., Oraby, A. H.: Optical and dielectric characteristics of polyethylene oxide/sodium alginate-modified gold nanocomposites. *RSC Adv.* **10**(62), 37621-37630 (2020)

16. Flores-Hernández, C. G., Cornejo-Villegas, M. D. L. A., Moreno-Martell, A., Del Real, A.: Synthesis of a Biodegradable Polymer of Poly (Sodium Alginate/Ethyl Acrylate). *Polymers*, **13**(4), 504 (2021)
17. Harun, M. H., Saion, E., Kassim, A., Mahmud, E., Hussain, M. Y., Mustafa, I. S.: Dielectric properties of poly (vinyl alcohol)/polypyrrole composite polymer films. *J. Adv. Sci. Arts*, **1**(1), 9-16 (2009)
18. Hussein, E. M., Desoky, W. M., Hanafy, M. F., Guirguis, O. W.: Effect of TiO₂ nanoparticles on the structural configurations and thermal, mechanical, and optical properties of chitosan/TiO₂ nanoparticle composites. *J. Phys. Chem.* **152**, 109983 (2021)
19. Jamróz, E., Kulawik, P., Kopel, P.: The effect of nanofillers on the functional properties of biopolymer-based films: A review. *Polymers*, **11**(4), 675 (2019)
20. Khalil, K. D., Bashal, A. H., Khalafalla, M., Zaki, A. A.: Synthesis, structural, dielectric and optical properties of chitosan-MgO nanocomposite. *J. Taibah Univ. Sci.* **14**(1), 975-983 (2020)
21. Kickelbick, G.: Concepts for the incorporation of inorganic building blocks into organic polymers on a nanoscale. *Prog. Polym. Sci.* **28**(1), 83-114 (2003)
22. Kocyigit, A., Yilmaz, M., Aydogan, S., Incekara, U., Sahin, Y.: The performance of chitosan layer in Au/n-Si sandwich structures as a barrier modifier. *Polym Test.* **89**, 106546 (2020)
23. Kunz, D. A., Schmid, J., Feicht, P., Erath, J., Fery, A., Breu, J.: Clay-based nanocomposite coating for flexible optoelectronics applying commercial polymers. *ACS nano* **7**(5), 4275-4280 (2013)
24. Li, F., Mascheroni, E., Piergiovanni, L.: The potential of nanocellulose in the packaging field: a review. *Packag. Technol. Sci.* **28**(6), 475-508 (2015)
25. Murri, R., Schiavulli, L., Pinto, N., Ligonzo, T.: Urbach tail in amorphous gallium arsenide films. *J. Non. Cryst. Solids* **139**, 60-66 (1992)
26. Othman, S. H., Kechik, N. R., Shapi'i, R. A., Talib, R. A., Tawakkal, I. S. Water sorption and mechanical properties of starch/chitosan nanoparticle films. *J. Nanomater.* **2019** (2019)
27. Qiu, J., Wang, L., Uchiya, K., Sakai, E. Effects of injection molding conditions on the electrical properties of polycarbonate/carbon nanotube nanocomposites. *Polym. Compos.* **37**(11), 3245-3255 (2016)
28. Rashad, M., Rüsing, M., Berth, G., Lischka, K., Pawlis, A.: CuO and Co₃O₄ nanoparticles: synthesis, characterizations, and Raman spectroscopy. *J. Nanomater.*, **2013** (2013)
29. Rashad, M.: Tuning optical properties of polyvinyl alcohol doped with different metal oxide nanoparticles. *Opt. Mater.* **105**, 109857 (2020)
30. Shetty, S. K., Ismayil, Shetty, G.: Enhancement of Electrical and Optical Properties of Sodium Bromide Doped Carboxymethyl Cellulose Biopolymer Electrolyte Films. *J. Macromol. Sci. Phys. B* **59**(4), 235-247 (2020)
31. Taghizadeh, S. M., Lal, N., Ebrahiminezhad, A., Moeini, F., Seifan, M., Ghasemi, Y., Berenjian, A.: Green and economic fabrication of zinc oxide (ZnO) nanorods as a broadband UV blocker and antimicrobial agent. *J. Nanomater.* **10**(3), 530 (2020)

32. Tang, Y., Hu, X., Zhang, X., Guo, D., Zhang, J., Kong, F.: Chitosan/titanium dioxide nanocomposite coatings: Rheological behavior and surface application to cellulosic paper. *Carbohydr. Polym.* **151**, 752-759 (2016)
33. Tharanathan, R. N.: Biodegradable films and composite coatings: past, present and future. *Trends Food Sci Technol* **14**(3), 71-78 (2003)
34. Vilela, C., Pinto, R. J. B., Pinto, S., Marques, P., Silvestre, A., Barros, C. S. D. R. F.: Polysaccharides-Based Hybrids with Metal Nanoparticles. *Springer Cham.* 9-30 (2018)
35. Xu, D., Chen, T., Liu, Y.: The physical properties, antioxidant and antimicrobial activity of chitosan–gelatin edible films incorporated with the extract from hop plant. *Polym. Bull.* **78**(7), 3607-3624 (2021)
36. Xu, T.: Ion exchange membranes: state of their development and perspective. *J. Membr. Sci.* **263**(1-2), 1-29 (2005)
37. Yang, Y., Chen, X., Li, Y., Yin, Z., Bao, M.: Construction of a superhydrophobic sodium alginate aerogel for efficient oil absorption and emulsion separation. *Langmuir* **37**(2), 882-893 (2021)
38. Yu, J., Wang, L., Zhao, Y., Zhou, C.: Preparation, characterization, and antibacterial property of carboxymethyl cellulose derivatives bearing tetrabutylammonium salt. *Int. J. Biol. Macromol.* **176**, 72–77 (2021)
39. Zhao, X., Wang, X., Lou, T.: Preparation of fibrous chitosan/sodium alginate composite foams for the adsorption of cationic and anionic dyes. *J. Hazard. Mater.* **403**, 124054 (2021)

Figures

Figure 1

UV-Vis absorption spectra of pure Cs, Cs substituted with 2, 4, 6 and 8 wt% of CuO, and Cs with 2 wt% of GO

Figure 2

UV-Vis. absorption spectra of pristine CMC, CMC with 2, 4, 6 and 8 wt% of TiO_2 , and CMC with 2 wt% GO

Figure 3

UV–Vis absorption spectra of pristine Na-Alg, Na-Alg with 2, 4, 6 and 8 wt% of TiO_2 , and Na-Alg with 2 wt% GO

(a)

(b)

(c)

Figure 4

Relation between $(\alpha h\nu)^2$ and photon energy ($h\nu$) for **a** pure Cs; **b** Cs/CuO nanocomposite with different concentrations of CuO (2, 4, 6 and 8 wt%); and **c** Cs/GO nanocomposite

Figure 5

Relation between $(\alpha h\nu)^2$ and photon energy ($h\nu$) for **a** pure CMC; **b** CMC/CuO nanocomposite with different concentrations of CuO (2, 4, 6 and 8 wt%) and **c** CMC/GO nanocomposite

(a)

(b)

Figure 6

Relation between $(\alpha h\nu)^{1/2}$ and photon energy ($h\nu$) for **a** pure CMC; **b** CMC/CuO with different concentrations of CuO (2, 4, 6 and 8 wt%) and 2 wt% GO

Figure 7

Relation between $(\alpha h\nu)^2$ and photon energy ($h\nu$) for **a** pure Na-Alg; **b** Na-Alg/2 wt% CuO; **c** Na-Alg /4 wt% CuO; **d** Na-Alg/6 wt% CuO **e**; Na-Alg/8 wt% CuO; **f** Na-Alg/2 wt% GO