Synthesis PEO/PS/PMMA/Se as new nanocomposite with porous morphology

K. A. Mohammed[a,*], R. A. Talib[b], S. Algburi[c], A. Kareem[d], B. Bhavani[e], M. A. Alkhafaji[f], R. S. Zabibah[g], F. H. Alsultany[h], S. Sharma[i,j]
[a]*Faculty of Pharmacy, Jabir Ibn Hayyan Medical University, Najaf, Iraq*
[b]*Polymer research center, University of Basrah, Basra, Iraq*
[c]*Computer Engineering Techniques Department, College of Engineering Techniques, Al-Kitab University, Iraq*
[d]*Department of medical physics, Hilla University College, Babylon, Iraq*
[e]*Department of Civil Engineering, Institute of Aeronautical Engineering, Hyderabad, Telangana, India*
[f]*National University of Science and Technology, Dhi qar, Iraq*
[g]*Medical Laboratory Technology Department, College of Medical Technology, The Islamic University, Najaf, Iraq.*
[h]*Department of Medical Physics, Al-Mustaqbal University College, 51001, Hillah, Babil, Iraq*
[i]*Mechanical engineering Department, University Center for research and Development, Chandigarh University, Mohali, Punjab, 140413, India*
[j]*School of mechanical and Automotive engineering, Qingdao University of Technology, 266520, Qingdao, China*

Novel nanocomposite structure has been made from physical mixing of polymer blend consist PMMA, PEO and PS filled with selenium nanoparticles. The nanocomposite had been deposited on glass slide by drop casting to form a thin film. This film was examined by required instrument like FESEM, XRD, EDS and UV-Vis to show the main physical properties of it. The XRD results were reflected the crystallinity nature of selenium NPs. SEM result shows the porosity nature of prepared film , where the pore size ranging from nano to micro size on all the surface of film. Also the indirect and direct bandgaps estimated and presented and equal to 3.77 and 4 eV.

(Accepted September 2, 2023; Accepted December 5, 2023)

Keywords: polymer blend; nanocomposite; Selenium nanoparticles; nanoporous; morphological properties.

1. Introduction

Selenium was known as a notorious element until it was recognized by Schwarz and Foltz in 1957 as an essential trace element for both plants and mammals. Normally Se is available as selenate and selenite oxoanions [1]. Selenium is a semiconductor of the p-type that holds significant importance in several applications. The substance has a very low fusion temperature of approximately 490 K, possesses a high refractive index, and displays a wide range of birefringence. The material possesses an indirect band gap of 1.85 eV. It exhibits the ability to conduct electricity through a photovoltaic effect and demonstrates high photoconductivity of 8 × 104 Scm−1. Under illumination, the material's conductivity can be significantly enhanced, potentially reaching thousands of times its original value. These characteristics highlight the potential of selenium in various applications. Photovoltaic devices, light-sensitive detectors, rectifying devices, and other similar applications [2,3]. Selenium NPs have been employed for therapeutic applications, including the treatment of fungal infections, microbial infections, diabetes, and cancer. However, there have been reports indicating that these nanomaterials are utilized in the development of more efficient nanowire electronics, sensors, and solar cells. In recent times, there has been a growing trend in the development of Selenium Nanoparticles

* Corresponding author: kahtan.a.mohammed@jmu.edu.iq
https://doi.org/10.15251/CL.2023.2012.863

(SeNPs) for their application in antimicrobial coatings as well as nutritional supplements for both food and feed purpose [4,5].

Polymer blending is a contemporary approach in the advancement of polymeric materials, wherein a minimum of two polymers are combined to generate a novel polymeric matrix. In order to address the limitations of polymeric samples and raise their conductivity, researchers employ the techniques of polymer blending and the incorporation of plasticizers to augment the AC conductivity [6-8]. The selenium based nanocomposite is very interested area for many research groups around the world because of the diversity of applications of these composite. Polymeric thin biofilms composed of polyvinyl alcohol (PVA) and sodium alginate (SA), which were doped with varying mass fractions of synthetic selenium nanoparticles, were effectively manufactured utilizing a conventional solution casting method by Amr M. Abdelghany and his research team [9]. In their study, Dhee P. Biswas and colleagues conducted an investigation on the individual loading of these substances into porous chitosan/polyvinyl alcohol (CS/PVA) scaffolds using a straightforward in situ deposition technique. This approach aimed to produce two unique wound dressing materials, namely CS-Se and CS-Ag [10]. A research group led by A.A. Menazea produced a blend of Polyvinyl Alcohol/Chitosan doped with selenium nanoparticles using a one-step laser ablation technique. The purpose of this synthesis was to enhance the antibacterial activity of the pure blend. The study aimed to investigate the impact of two different selenium concentrations on the optical, structural, and morphological aspects of the nanocomposite films made using PVA/Chitosan/SeNPs. The investigation focused on examining the antibacterial activity of the generated samples [11]. The utilization of the laser ablation procedure for the production of selenium nanoparticles (Se NPs) was investigated in a study undertaken by Eman Alzahrani. Polyethylene oxide (PEO) and chitosan (Cs) were dispersed in a ratio of 70% PEO to 30% Cs, and afterwards subjected to scattering by selenium nanoparticles (Se NPs) at different ablation durations. The UV-Visible spectra are employed for the analysis of the optical characteristics of the polymer nanocomposites, namely the PEO/Cs/Se NPs. The increase in the concentration of selenium nanoparticles in the blend resulted in a decrease in the direct transition energy gap, reducing it from 5.35 to 4.96 [12]. A mixture comprising of polyethylene oxide (PEO) and polyvinyl alcohol (PVA) was fabricated by A.L. Waly and colleagues by the utilization of a typical casting method. This mixture was further enhanced by the incorporation of selenium nanoparticles (SeNPs) with varying quantities, resulting in a gradient distribution inside the composite material. The evaluation was conducted to assess the impact of variations in selenium content on the structural, optical, and surface features of the nanocomposite films under investigation. Research on characterization has indicated that the combination guarantees a consistent and regulated dispersion of selenium nanoparticles (SeNPs) throughout the polymer matrix [13]

Nanoporous materials are classified as a significant category of nanostructured materials due to their distinctive surface and structural properties [14]. These properties include a large surface area, adjustable pore sizes and geometries, as well as porous architectures that exhibit surface topographies [15-18].

The objective of this work is to create a new composite material consisting of a blend of PEO/PS/PMMA packed with Se NPs. This will be achieved by a conventional physical mixing technique. Additionally, a thin film will be prepared by employing the drop casting method using our composite material.

2. Experiment work

To achieve the final nanoporous thin film, three main steps were made , first the preparation of polymer blend by dissolve identical mass from PEO, PS and PMMA in acetone separately, after that we mix the three polymer solution together. Second, 100 mg from Se nanoparticles was added to thr polymer blend solution and stirred om magnetic stirrer for 5 hour to make homogenous and clear solution. Finally, the composite was dropped on surface of glass slide to prepare a thin film. The dried film was tested by SEM, XRD, EDS and UV-VIS to examined the physical properties.

3. Results and discussion

X-ray diffraction (XRD) research was conducted utilizing a Powder X-Ray Diffractometer in order to validate the crystal structure of the composite material. The primary objective of this X-ray diffraction (XRD) research was to validate the existence of elemental selenium nanoparticles within the polymer matrix. The research findings revealed a distinct peak at a 2θ value of 22.63 and 29.71, as illustrated in Figure 1 [19,20]. The additional peaks observed in the X-ray diffraction (XRD) spectrum could potentially be ascribed to the diffraction peaks originating from the polyethylene oxide (PEO) polymer. Table 1. Show the main information about crystal structure of composite.

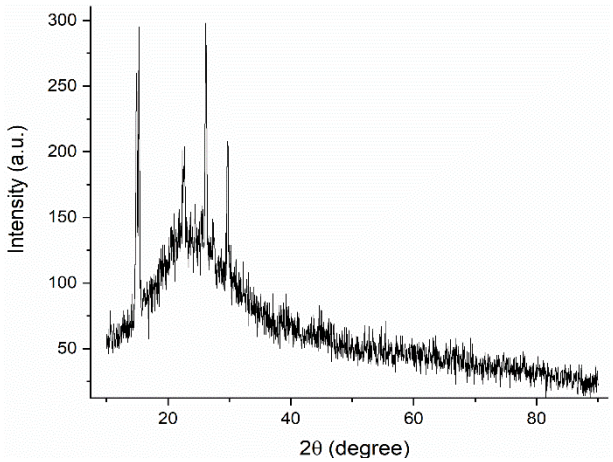

Fig. 1. XRD peaks of PEO/PS/PMMA/Se composite.

Table 1. XRD peaks information of PEO/PS/PMMA/Se composite.

Pos. [°2Th.]	Height [cts]	FWHM [°2Th.]	d-spacing [Å]	Rel. Int. [%]
14.888	152	0.24	5.94561	86.17
15.288	175	0.21	5.79091	99.32
22.63	63	2.9	3.92639	35.92
26.183	176	0.32	3.40083	100.00
29.71	121	0.33	3.00417	68.36

The SEM results was illustrated in figure 2. Figure 2 show the porosity nature of prepared film , where the pore size ranging from nano to micro size on all the surface of film.

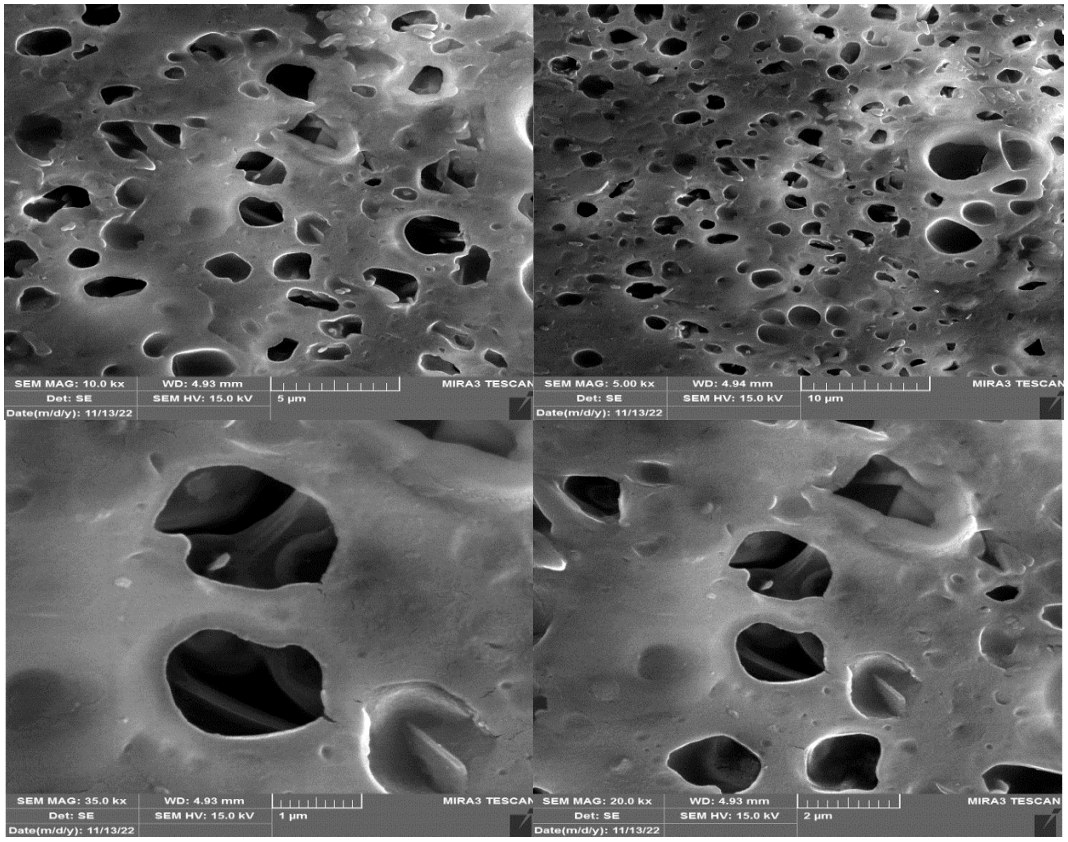

Fig.2. FESEM of PEO/PS/PMMA/Se composite.

Additionally, the chemical composition of the produced nanocomposite was verified by Energy Dispersive X-ray Spectroscopy (EDX). The presence of major elements in the nanocomposite is also indicated by the EDX spectra, as depicted in Figure 3. The presence of oxygen and carbon peaks in the polymers can be attributed to the composition of the raw ingredients used.

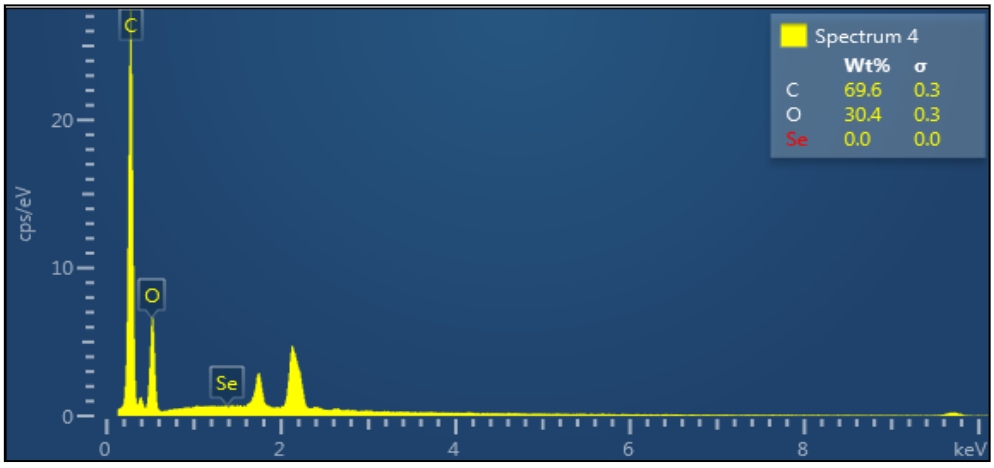

Fig. 3. EDS spectrum of PEO/PS/PMMA/Se composite.

The optical properties of the PEO/PS/PMMA/Se composite were examined through regular measurements within the spectral range of 200-1000 nm, as depicted in Figure 4. The data

shown in Figure 4 illustrates the maximum transmission observed for the composite material under investigation. There is a substantial decrease in transmittance throughout the UV-visible range. Consequently, the incident light undergoes absorption or dispersion, resulting in a substantial reduction in transmissions. The aforementioned property might be regarded as an innovative implementation for ultraviolet (UV) blockage and laser attenuation [21,22].

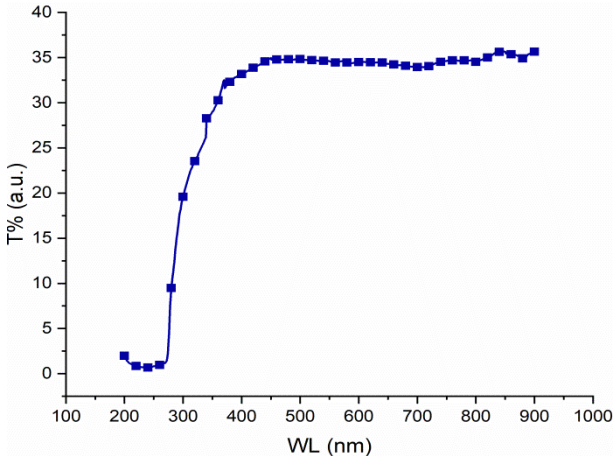

Fig. 4. Transmittance spectrum of PEO/PS/PMMA/Se composite.

Figure 5 shows the UV-visible absorption spectrum of PEO/PS/PMMA/Se nanocomposite. it shows a sharp peak at around 243 nm, This peak is representative of Surface Plasmon Resonance (SPR) caused by the presence of conduction electrons in the SeNPs' surface [23] . This peak may be due to the overlapping of the absorption spectrum of polymers with the peak of the selenium nanoparticles, this finding matches the behavior of the materials in ref. [24].

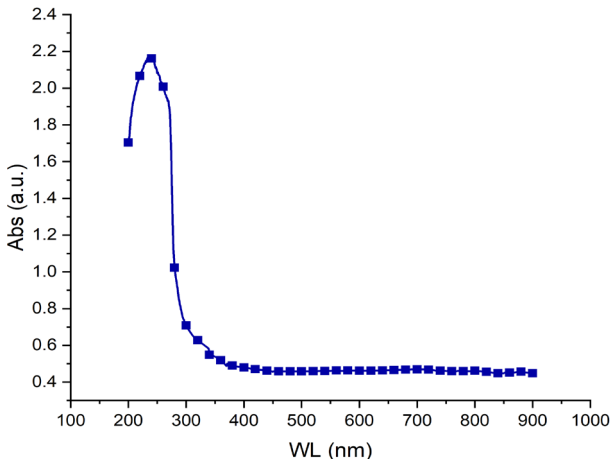

Fig. 5. Absorbance spectrum of PEO/PS/PMMA/Se composite.

Figure 6 illustrates the relationship between the absorption coefficient α (cm)-1 and photon energy for nanocomposite films consisting of PEO/PS/PMMA/Se. It is evident that the absorption coefficient exhibits its lowest value at lower energy levels. This implies that the likelihood of electron transition is low due to the insufficient energy of the incident photon to facilitate the movement of the electron from the valence band to the conduction band. At higher energy levels, it is seen that absorption is significantly enhanced [25].

Figure 7 shows the indirect bandgap of PEO/PS/PMMA/Se composite. The optical indirect band gap of PEO/PS/PMMA/Se is 3.77 eV as calculated from a Tauc plot.

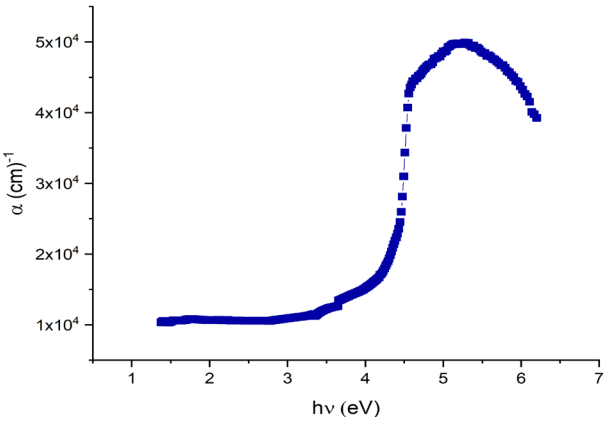

Fig. 6. Absorption coefficient of PEO/PS/PMMA/Se composite.

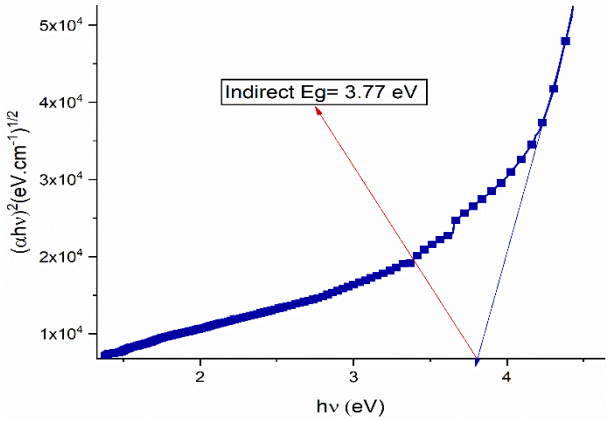

Fig. 7. The indirect bandgap of PEO/PS/PMMA/Se composite.

Fig. 8. shows the direct bandgap of PEO/PS/PMMA/Se composite. The optical direct band gap of PEO/PS/PMMA/Se is 4 eV as calculated from a Tauc plot. According to values reported in the literature, selenium and its composites exhibits a band gap energy value of 3.49-4.9 [26-28].

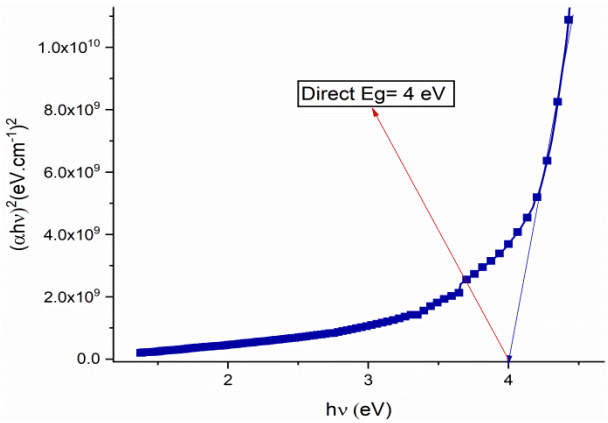

Fig. 8. The direct bandgap of PEO/PS/PMMA/Se composite.

4. Conclusions

A novel nanocomposite structure has been produced using the physical blending of a polymer blend comprising of polymethyl methacrylate (PMMA), polyethylene oxide (PEO), and polystyrene (PS), with the incorporation of selenium nanoparticles. The deposition of the nanocomposite onto a glass slide was achieved by the drop casting method, resulting in the formation of a thin coating.

The film underwent analysis using essential instruments such as FESEM, XRD, EDS, and UV-Vis in order to elucidate its primary physical characteristics. The X-ray diffraction (XRD) data demonstrated the crystalline character of selenium nanoparticles (NPs).

The results obtained from the scanning electron microscopy (SEM) analysis indicate that the produced film exhibits a porous structure, with pore sizes ranging from the nanoscale to the microscale observed along the whole surface of the film. The estimated values for both the indirect and direct bandgaps are shown as 3.77 eV and 4 eV, respectively.

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