Structural and Optical Properties of Flexible Polymer Nanocomposites Films for Optoelectronics Applications

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ABSTRACT

In this study, we address the effects of low energy hydrogen ion beam irradiation on the optical characteristics of polymeric nanocomposite films for used in optoelectronics devices. The composite films are irradiated using broad beam cold cathode ion source with hydrogen ion energy ranging from 1 to 6 keV. The techniques of X-ray diffraction, Fourier transform infrared spectrum, as well as scanning electron microscopy are all used to investigate the untreated and irradiated films and determine their properties. Both the optical energy band tails and the optical energy bandgap of untreated as well as modified films were determined. The FTIR peaks are indicative of inorganic nanoparticles bound to the polymer chains, and XRD validated the successful synthesis of the polymeric composite films. Scanning electron microscopy (SEM) pictures have shown that the nanofillers is loaded and distributed uniformly throughout the polymeric layer. Moreover, the refractive index, extinction coefficients, and dispersion properties were also established for the pure and treated films. On the other hand, the ion penetration depths, the electronic stooping, nuclear energy loss and distributions of scattered atoms are recorded using SRIM program. In light of these findings, the irradiated flexible composite films with low energy hydrogen ion beam can be used in a variety of fields, including those dealing with batteries, super-capacitors, detectors, as well as optoelectronics.

INTRODUCTION

Irradiated flexible film composites are significant because they improve thermal stability as well as electrical conductivity by combining irradiation technologies with polymer features like durability and ductility [1-3]. By tailoring the ion irradiation settings and polymer chains, the physical characteristics of the composite substances can be altered for specific device usages [4,5]. Irradiating flexible composite films to improve their conductivity is the main focus of the current study [6]. For many applications, the fact that flexible composites are also recycled, non-toxic, and extremely soluble in water makes them the substance of choice [7].

The distinctive characteristics of composites, such as their manageability, compactness, adaptability, ease of manufacturing, the cost-effectiveness and powerful mechanical capabilities [8, 9], have been gaining significant attention in devices manufacturing.

OBJECTIVES

The main goals of this study include :

1 Preparation of flexible composite films via solution casting.
2 Analyzing the structure-related properties of the prepared samples.
3 Examining the surface morphology of the composite films that have been prepared.
4 Investigating the impact of ion irradiation on the physical properties of composite materials.
5 Determining the modifications in the irradiated films using the SRIM/TRIM simulation procedure.

METHODS

The samples will be studied utilizing various methodologies as shown in Figure 1.

1. The XRD is used to identify the crystalline structure of the prepared films
2. The FTIR spectroscopy is used to identify the chemical structure of the prepared films
3. The SEM is used to validate the surface morphology and degree of homogeneity
4. The UV/VIS is evaluate the absorption and reflection spectra of the untreated and exposed films over the wavelength of 190 to 1050 nm
5. On the other hand, the SRIM/TRIM simulation method is used to determine the penetration of ions in the polymer.

EXPERIMENTAL SETUP

The Ion source system source is shown in Fig. 2. It consists of a cathode and anode and a potential difference between them. The beam is accelerated to the exit . The ion beam comes out to interact with the composite, and the changes occurring on the surface of the composite are studied**.**

RESULTS

The absorption coefficient (α) is given by applying the Beer-Lambert relation [9]:

$$\alpha = \frac{2.303\ A}{t} \qquad (1)$$

Absorption coefficients (α) versus incident photon energy ($h\nu$) for untreated and irradiated PVA/NaI composites are shown in Figure 3. Blank and irradiated sample absorption edge values are determined. After irradiation, we saw that the absorption edge (E_e) shifted to a higher photon energy. These shifts towards the higher and lower photon energy indicate the change in band gap after irradiation.

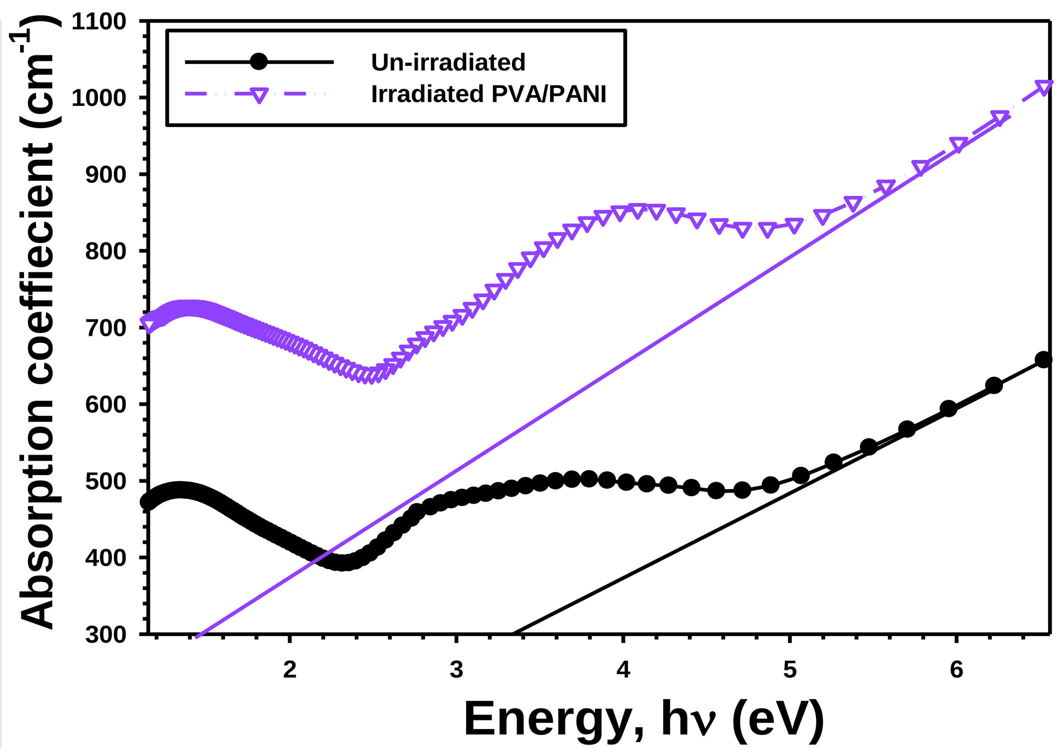

Fig.3: The absorption coefficient (α) versus the ($h\nu$), of the pristine and irradiated PVA/PANI composite samples.

The index (n) of the pristine and irradiated samples given by [10]:

$$n = \frac{(1+R)}{(1-R)} + \sqrt{\frac{4R}{(1-R)^2} - K_o^2} \qquad (2)$$

Figure 4 exhibits the refractive index with wavelength of 190 nm to 1100 nm. The results reveal that n values significantly increase upon irradiation. These changes in values of n with irradiation is owing to the chain scission process.

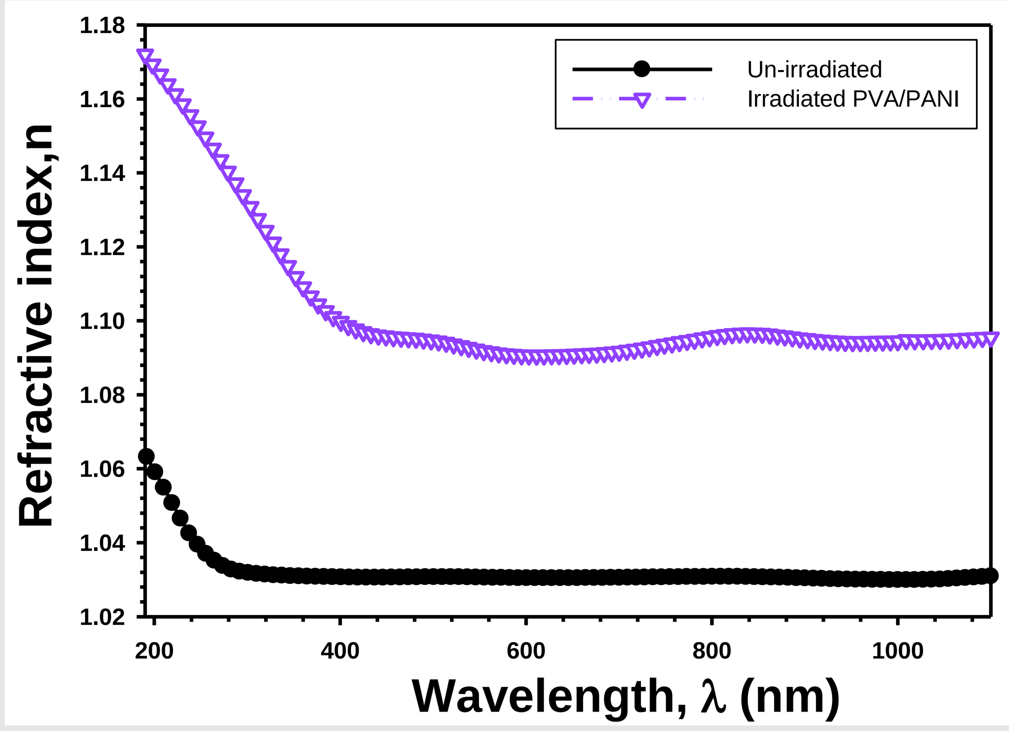

Fig.4: The refractive index of the pristine and irradiated PVA/PANI composite samples

CONCLUSIONS

The use of irradiation nanocomposite films in optical systems was investigated, and a simple and new method was developed. In recent years, most researchers have used to develop flexible polymers. For industrial purposes, hydrogen ion beams are utilized to irradiate these polymers. The samples in this work were made using the solution castings preparations technique. Characterization methods include X-ray diffraction (XRD), scanning electron microscopy (SEM), and Fourier transform infrared spectroscopy (FTIR). Polymeric films have had their characteristics enhanced by ion irradiation, making them suitable for a wider range of applications. This study demonstrated that basic, adaptable approaches can bring out hitherto unseen novel properties and unique applications in irradiation composite substances. The irradiation composite will be used in a wide range of optical device uses according to the findings of this study.

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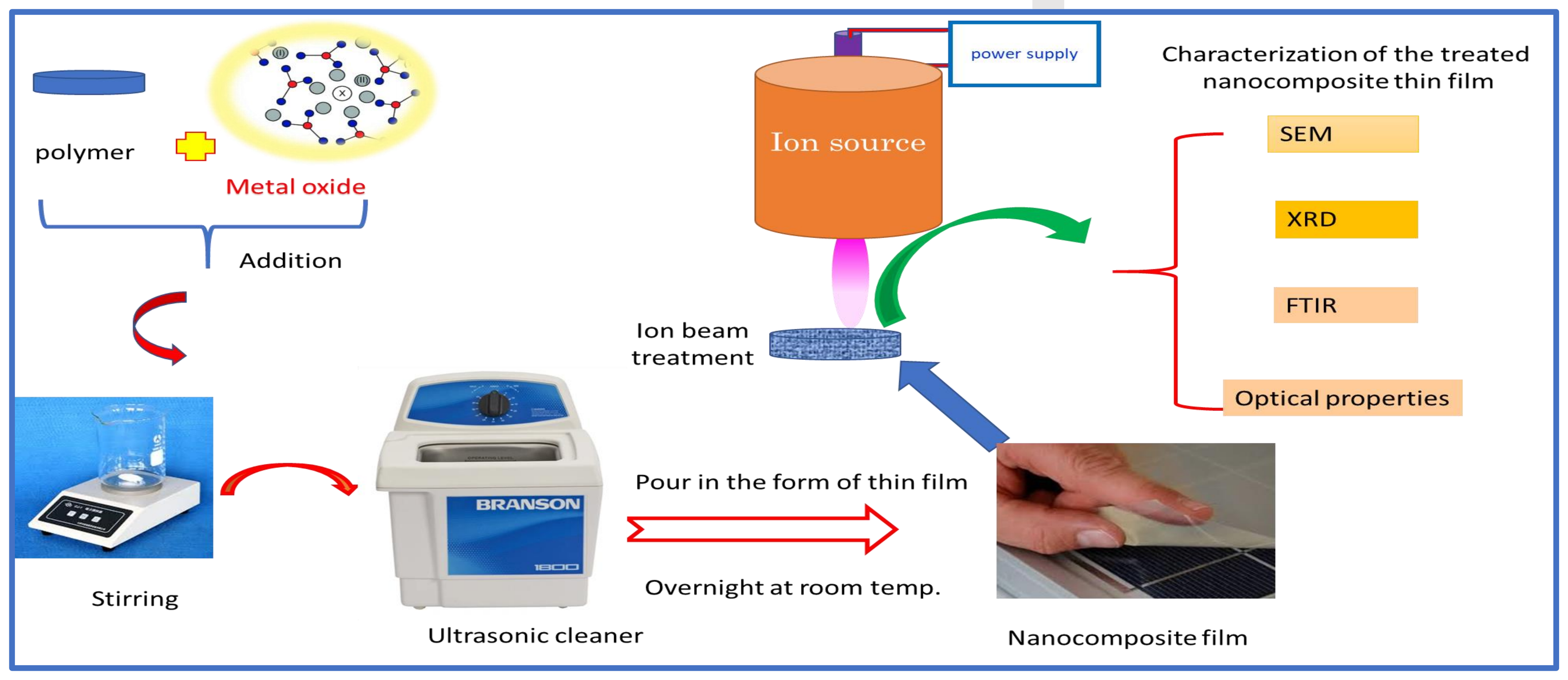

Fig.1 Sample Preparation and characterization methods

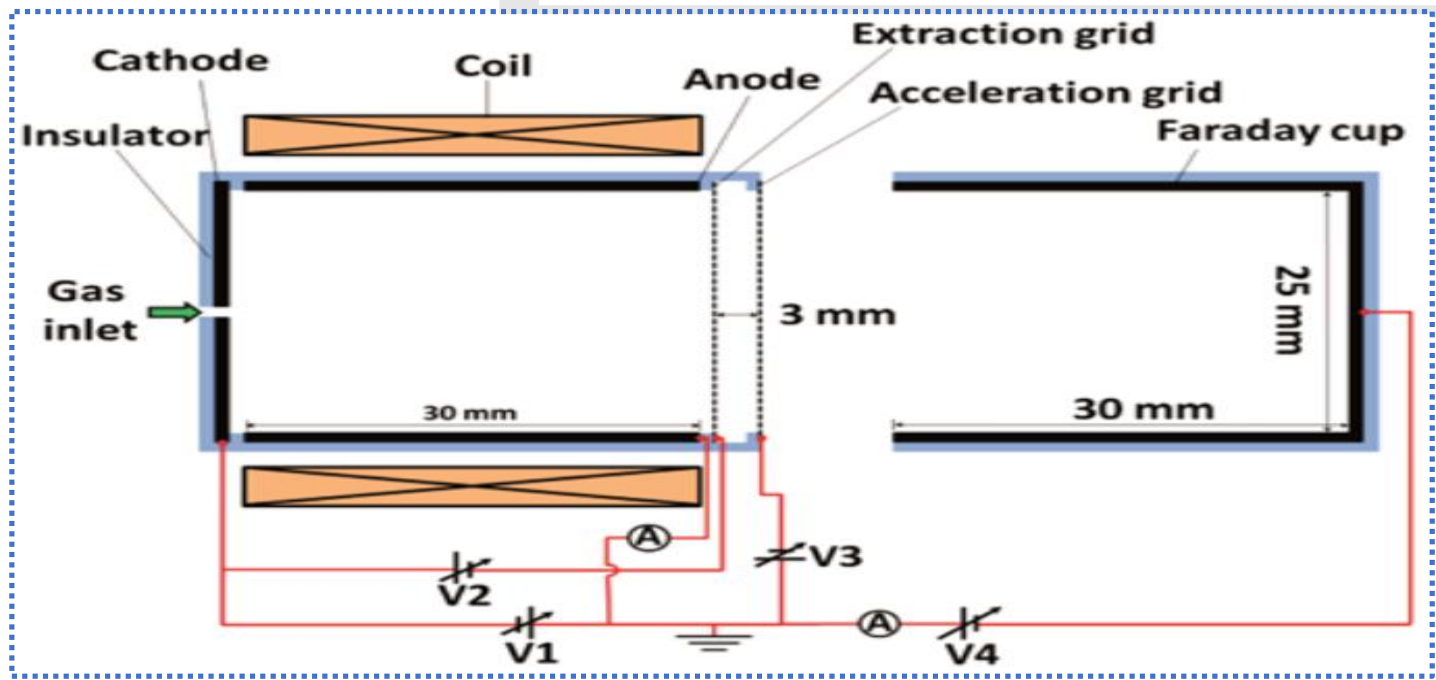

Fig. 2 Ion source with electrical circuits