International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 1 Volume No.9 January - February – 2025
DOI:10.46647/ijetms.2025.v09i01.003 ISSN: 2581-4621

Electron Beam Irradiated Studies on Conducting Polymer Composites for Energy Storage Applications

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Abstract
Conducting Polymer composites were prepared by chemical reaction method. Synthesiszed composites were characterized by XRD,SEM,TEM & FTIR.FTIR gives the confirmation about Interaction between the molecules, from XRD we understand the Crystalinity of samples and SEM helps to understand the morphological behavior of Samples .Irradiation studies confirms that these nanocomposites are suitable for Energy Storage ,Electrochromic & Optoelectronics devices.
Keywords: SEM,XRD,FTIR,PPY,DSC

1 Introduction

Conducting Polymer nanocomposites shows great interest in many area of applications such as electromagnetic shielding,anti corrosion ,biosensor and biomedical[1-5]. Conducting polymers have attracted considerable interest because of their excellent physical and chemical properties originating from their conjugated system The widely exploited properties of conducting polymers in technological and commercial applications are their thermally withstanding capacity, bio-compatibility, electrical conductivity, switching capability between conducting-oxidized and insulating-reduced state .Among conducting polymers, polyaniline family has attracted much attention of scientists world-wide because of their ease of synthesis, unique conduction mechanism, high environmental stability in the presence of oxygen and water, low cost, light weight and good sensing capability. PANI can be prepared in various forms including thin films, powders, colloidal particles, composites and nanocomposites etc [6-16].

2 Materials and Methods:

Pyrrole (99.0%), Lithium perchlorate ($LiClO_4$) (mol.wt.106.4 g/mol), ammonium persulfate (APS, 98.0%) and hydrochloric acid (mol wt, 36.46 g/mol)were purchased from Sigma-Aldrich, USA. PPy/ Lithium Perchlorate ($LiClO_4$) composite was synthesized in 100 ml 1M HCl using ammonium dipersulphate $(NH_4)_2S_2O_8$ (APS) as an oxidizing reagent by chemical reaction method. The composite was irradiated using 8.1 MeV electron beam (EB) energy in the LINAC, RRCAT-Indore at 40, 80 and 120 kGy doses. The chemical change of the composite before and after EB irradiation was analyzed by Fourier transform infrared spectrometer (FT-IR, ALPHA BRUKER) in the spectral range of 2500-500 cm^{-1} and surface morphology has been observed using a Sigma Zeiss scanning electron microscope (SEM). XRD characterization done by using X-ray Diffractometer wavelength λ=1.5406Å and samples were scanned from 10 to 60º at the scanning rate of 10º per minute. Thermo gravimetric analysis (TGA) and Differential Thermal Analysis (DTA) are studied using Q-600 TA instruments heating from 30 to 800 ºC and from 30 to 300 ºC with heating rate of 10 ºC/min under nitrogen flow.

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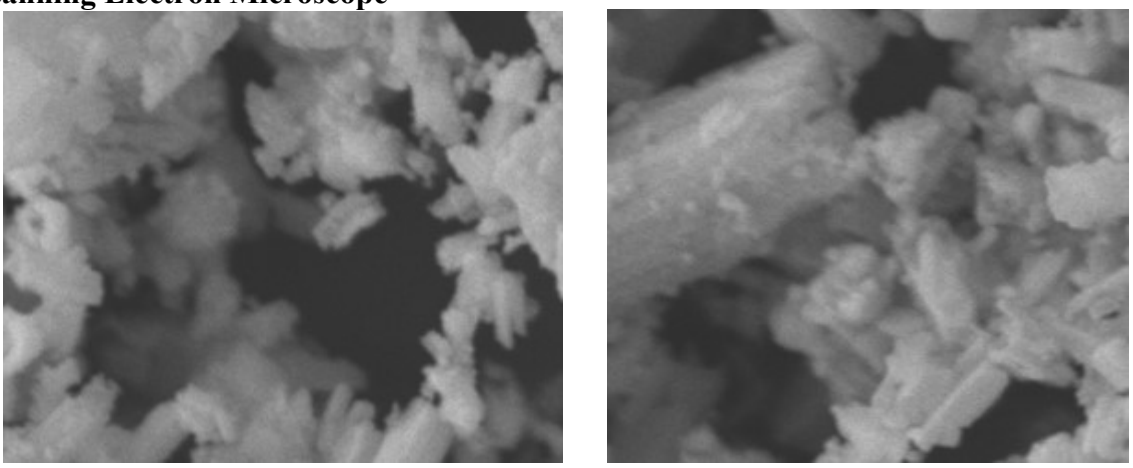
3 Results and Discussions

3.1 Scanning Electron Microscope



(a) (b)

Figure 3.1 shows the SEM images of Unirradiated a) PPY/Composite, b) EB irradiated PPY/Composite

Figure 3.1 shows SEM image of Electron beam irradiated and Unirradiated of pure PPy and PPy composites The clear observation of SEM image of plain PPy shows some pores, which are usually observed due to some deformation of polymer film during casting. However in some streaks with disjoints are also observed in the image. Composite images show that, the fine dispersion of salt particles in the PPy matrix is observed, irregular shaped particles with compacting nature of the particles are also observed.

3.2 FT-IR ANALYSIS

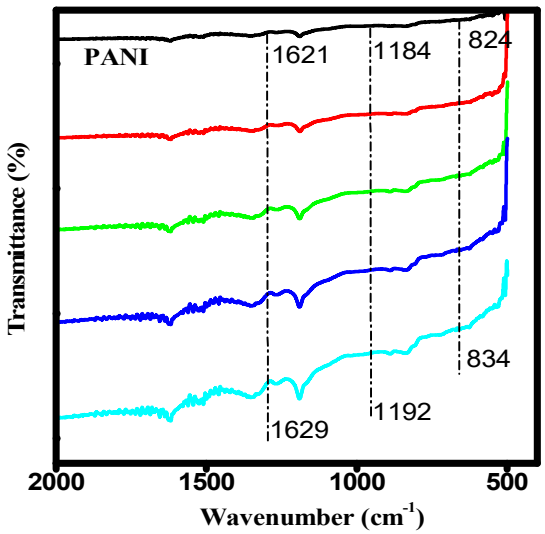


Figure 3.2: FTIR spectra of unirradiated and EB irradiated PPy nanocomposite

Figure 3.2 shows he FTIR of PPY/Composites the band at 824 cm^{-1} is due to CH_2 bending vibration,its seem to be decrease in irradiation dose this may create the destruction of structure of polymer .the intensity peak at 1621 is due to C=C group it represents the occurrence of cross-linking .The peak intensity is increased and transmittance is decreased in EB irradiated films with

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respect to that of gamma irradiated films. Also, these results suggest that the affects are more pronounced in electron beam compared to that of gamma ray irradiation.

3.3 XRD Analysis

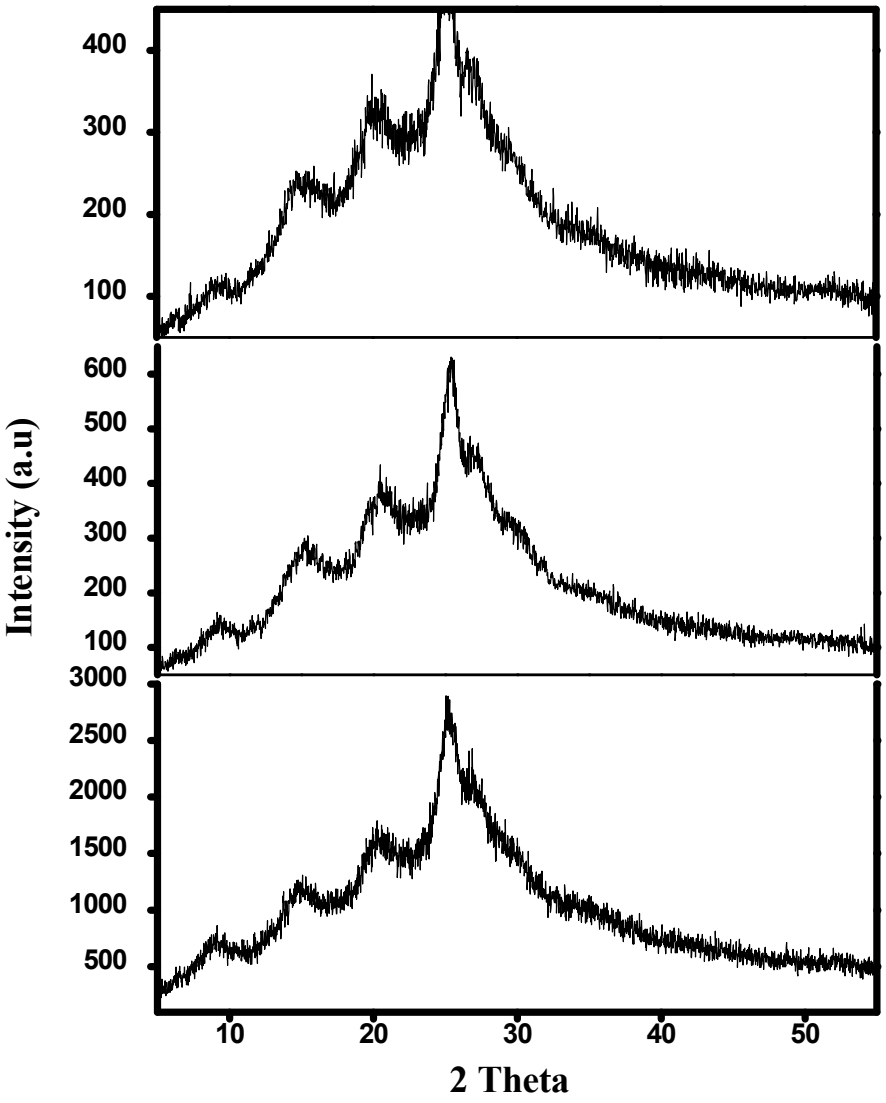

Figure 3.3: XRD spectra of PPy, unirradiated PPy composite and EB 120 kGy dose irradiated PPy composite.

Figure shows the XRD image and it is clearly indicates the effect of the radiation dose on the structural phase of PPy composites.Partly crystallinity and amorphous phase found in non –irradiated samples and also there is changes in structurel parameter after irradiation which eefects crystallinity phase of the polymer ; The increase in FWHM (β) and peak intensity (I) is clearly represent the decrease in crystallinity non irradiated compared to EB-irradiated smples. These results suggest that EB irradiation is more effective on Conducting polymer samples.

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3.4 Thermal Studies

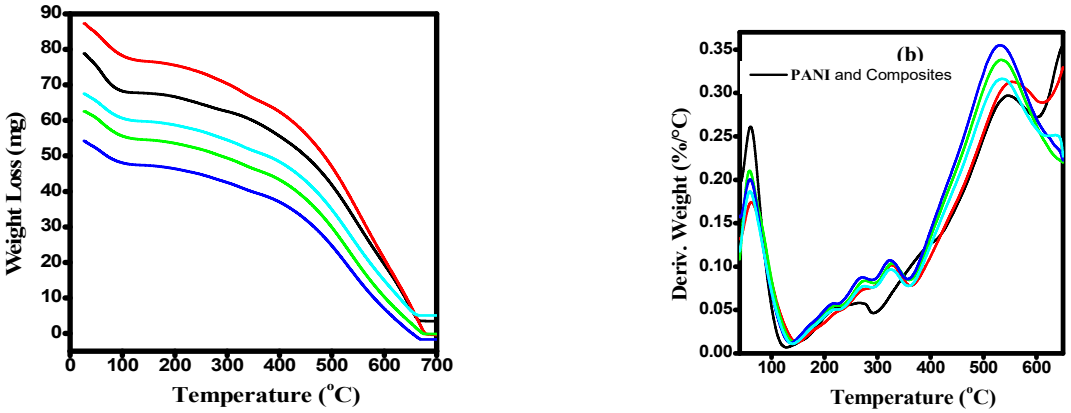

Figure 3.4: (a) TGA, (b) DTA curves of PANI, unirradiated and EB irradiated PALi composite.

Substituting for the heat flow by the TGA DTA then the heat capacitance C_p can be estimated against temperature. Fig. 3 represents the temperature dependence of the heat capacitance of PPy nanocomposite. According to Fig 3, the heat capacitance of Polypyrrole / nanocomposite is close to that of nano particles at room temperature. However as the temperature increase the divergence between Polypyrrole /Nonocomposites increase. As the temperature increase the heat capacitance of both ,continuously increase.

3.5 Transimmision Electron Microscopy

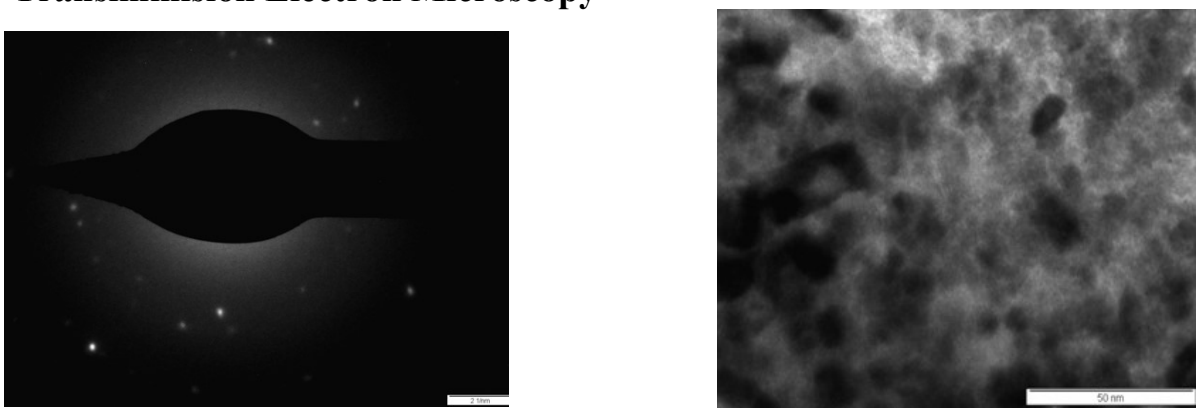

Figure 3.5 represent Transmission Electron Micrographs PPY Composites

Fig shows the TEM Image of PPy Composites particles are well interlinked with each other average particle size found 50nm .

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4 DC Conductivity

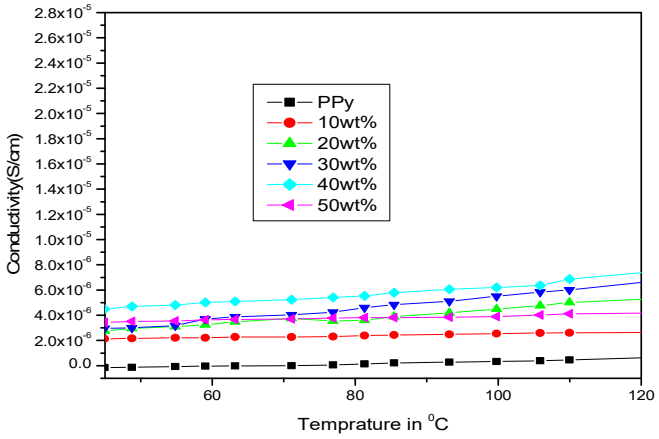

Figure 4 shows the DC Conductivity of PPY/Composites

Figure 4 shows the dc conductivity of PPy/ nanocomposites as a function of temperature which varies from 40 to120^{0}c. The conductivity values are almost constant up to 80^{o}c and after it increases steadily up to 120^{o}c, which shows the semiconducting material behavior. At higher temperature, conductivity increases because of hoping of charge carriers (polarans) from one localized state to another localized state. The increase in dc conductivity as a function of temperature of the PPy/ nanocomposites at different weight percentages. The conductivity increases with an increase in temperatures due to the flow of ions from one localized state to another and It is also suggested here that the thermal curling effects of the chain alignment of the PPy leads to the increase in conjugation length and that brings about the increase of conductivity.

Conclusion

We have investigated the EB irradiation induced modifications in PPy composite using FT-IR, XRD, SEM, and TGA ,DTA techniques. The results show the change in the crystallinity and chemical structures polymers after the irradiation by EB radiation. The modification in the irradiated samples was confirmed from FT-IR that the chain scissoning/branching occurs for both process, as the intensity of the wave number enhances with incremental irradiation. Another remarkable peak observed at 1621 cm^{-1} corresponds to the presence of C=C group. An increase in the intensity of this peak suggests the occurrence cross-linking.. In addition, the effects of EB irradiation on structural morphology was investigated by SEM, and the images reveal that after irradiation there is improvement in the surface morphology of the samples.

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