

# Structurally Fundamental Study of Polyaniline

H. S. Patel and D. H. Viroja  
Arts, Commerce and Science College, Borsad, Gujarat, India

**Abstract:** Electronically conducting polymers have a conjugated structure, i.e. alternating single and double bonds between the carbon atoms of the main chain. The X-Ray powder diffraction is used to obtain information about the structure, composition, and state of emeraldine base PANI materials. Some typical applications are: identification of an unknown based on the crystalline peaks, at room temperature studies, precise measurements of lattice constant and residual strains, and refinement of atomic coordinates. Scanning electron microscope (SEM) is involves scanning of an electron beam across a sample surface and secondary electrons are ejected from the surface. SEM images are used to examine the surface morphology and microstructure or to investigate the inner microstructure from fracture cross-sections. Since the visual observation has some limitations, the microstructural investigations of material require much higher resolution. Transmission electron microscopy with its high resolution capability offers itself as a suitable tool for this purpose. The PANI powder grain size in the range of around 150 nm.

**Keywords:** PANI, XRD, SEM, TEM

## I. INTRODUCTION

Conducting/Semiconducting polymers have been observed as edge area of research and potential materials for scientific applications since last decade [1-5]. The polymerization mechanism [6], processability [7], and transport mechanism [8] are the point of academic and scientific attractions. Technological applications include biosensors [9], gas sensors [10], electrochromic [11,12], electromagnetic shielding [13], light emitting devices [14] and photovoltaic applications [15,16]. The polyaniline is extensively studied polymer because of its high electrical conductivity, oxidative properties, structural properties, environmental stability and ease of preparation etc. [17, 18]. In this paper we have discussed the XRD, SEM and TEM of Polyaniline powder.

## II. EXPERIMENTAL PROCEDURE

The resulted emeraldine base PANI (having purity 99.98% Alpha Aesar, Lancs – U. K) was in a powder form which the characterization was carried out using several techniques. These techniques were Wide-Angle X-Ray analysis, Transmission electron microscopy and Morphological (SEM) analysis. The results of these analyses are discussed in detail in this Paper.

The X-Ray diffraction method is the most powerful technique available for the examination of polymers in the solid state. The X-Ray diffraction (XRD) experiments in present case was carried on an X-pert MPD X-Ray diffractometer Cu-K $\alpha$  anode radiation. The X-ray diffractogram was recorded in the  $2\theta$  range of  $3^\circ - 100^\circ$  employing the wavelength  $\lambda = 1.54056 \text{ \AA}$ . (at SICART, V. V. Nagar, Gujarat, India). SEM images are used to examine the surface morphology and microstructure or to investigate the inner microstructure from fracture cross-sections was carried out by ESEM EDAX XL-30, Philips, Netherlands (at SICART, V. V. Nagar, Gujarat, India). Transmission electron microscopy with its high resolution capability offers itself as a suitable tool for this purpose. PANI

(EB) was transferred on the grid of the Philips, Netherlands Model: Tecnai 20, (at SICART V. V. Nagar, Gujarat, India).

## III. RESULTS AND DISCUSSIONS

**XRD technique:** X-Ray diffraction spectra of emeraldine base PANI powder synthesized at room temperature is shown in figure 1.

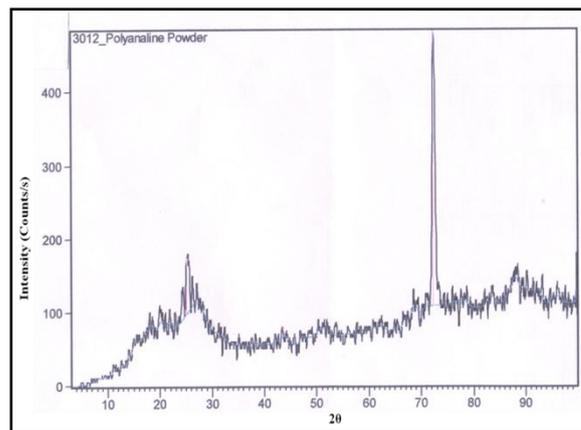


Figure 1: XRD of emeraldine base PANI powder

PANI crystallizes in the monoclinic space group  $P_{21}$ . The diffractograms show a well-developed crystallinity in the sample prepared at room temperature is nearly amorphous (Figure 1). According to the method suggested by Kelkar et al. [19] for any polymer, the resolution of the peak  $R$  is given by:

$$R = \frac{m_1 + 2m_2 + \dots + m_{n-1}}{h_1 + h_2 + \dots + h_n} \quad (1)$$

where  $m_1, m_2, \dots$  are the heights of minima between two peaks, and  $h_1, h_2, \dots$  are the heights of the peaks from the base line. Then  $(1-R)$  gives the lateral order or the index of crystallinity. Figure 1 indicates that the peak is quite sharp and well resolved; hence, the percentage crystallinity ( $X_c\%$ ) was calculated from equation 1 is found to be 1.23%. While the molecular weight reflects the macromolecular structure of polyaniline, the degree of crystallinity is associated with the supramolecular organization of polyaniline chains. For polyaniline samples, the fraction of crystalline phase increased as the molecular weight grew [20].

**SEM technique:** Studies on morphology of emeraldine base PANI are important for investigating the intrinsic characteristics of the polymer [21]. Many of the studies [22-25] are rudimentary and exploratory in nature. Figure 2 (a,b) shows the morphology of emeraldine base PANI powder [20].

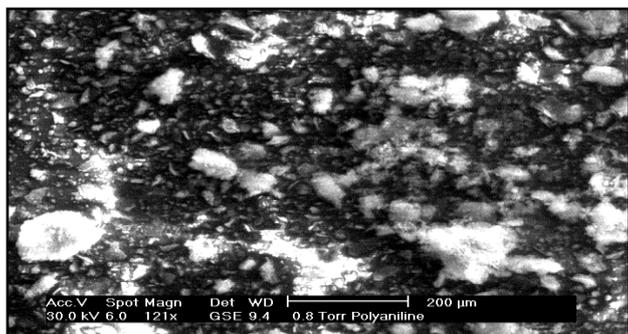


fig.1 (a)

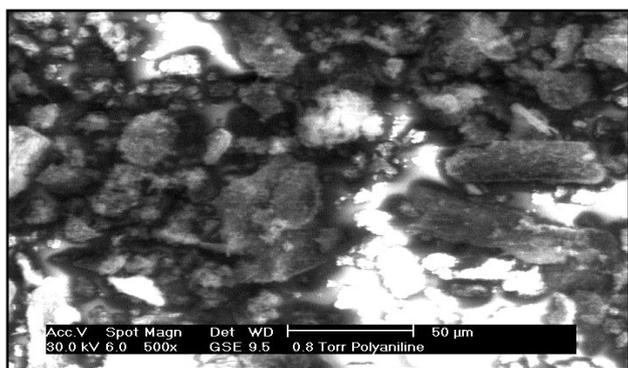


fig. 2 (b)

Figure 2 (a,b): SEM micrographs of Emeraldine base PANI powder.

**TEM Technique:** The images of PANI usually show the size of grain. The images of TEM observed in present case are shown in figure 3. The grain size of emeraldine base PANI powder is in the range of 136nm to 205nm [20].

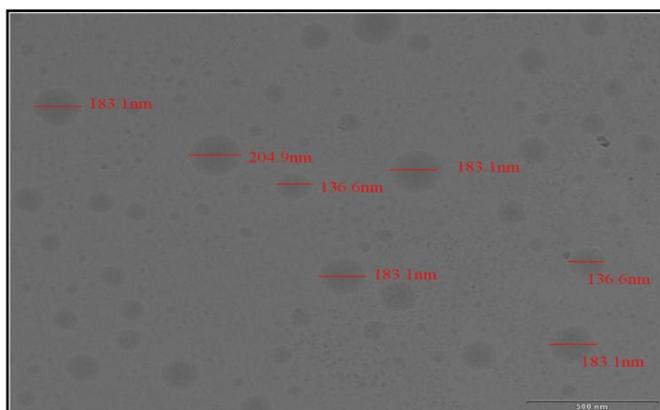


Fig 3:TEM image of emeraldine base PANI powder.

### CONCLUSION

From XRD in PANI, the fraction of crystalline phase increased as the molecular weight grew. The increase was more pronounced for the sample prepared at low temperature. This may indicate that chains pronounced under lower temperature conditions have less structural defects.

The SEM photographs show typical features of the polymer. Both photographs are mainly composed of irregularly arranged granular and flakes with sharp edges. Moreover, the structure looks more porous. The grain size of emeraldine base PANI powder is in the range of 136nm to 205nm.

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