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Complex optical studies on conducting polyindole as-synthesized through chemical route

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ABSTRACT

This research article reports the novel UV-vis spectroscopic studies on as-synthesized conducting polyindole (PIn) through chemical polymerization route at room temperature using anhydrous ferric chloride as an oxidant. The complex optical properties of derived samples were studied by using UV-vis spectroscopy. The as-synthesized polymeric samples exhibited absorption around 220–300 nm. The optical band gap was found to ranges over 4.630–5.224 eV. The maximum optical conductivity for 0.6 M $FeCl_3$ was found to be 7.93×10^8 S^{-1} at 275 nm. The estimated optical band gap accomplished that this material has potential applications in optical devices.

1. Introduction

Now days, in the development of new efficient and enhanced materials, there was rising research focus towards the synthesis of conducting polymers like polyaniline (PANi), polypyrrole (PPy) and polythiopene (PTh) due to their high electrical conductivity, interesting electrochemical properties, and easy processability [1–3]. These electrical and electrochemical properties of such conducting polymers show much assurance for commercial applications in battery materials [4], electrochromic devices [5], sensor technology [6], and nonlinear optics [7]. However, among various aromatic-compound-based conducting polymers, polyindole (PIn) has received excellent research interest due to its close structural similarities with the polymers mentioned above [8–10]. PIn is electroactive polymer, which can be derived either by chemical oxidation or by electrochemically oxidation of monomer using $FeCl_3$ or $CuCl_2$ as an oxidant [11]. PIn shows good thermal stability, high-redox activity and stability, and slow degradation rate in comparison with PANi and PPy [12-14].

The available literature reported that, PIn has been derived chemically by oxidation of indole using a supramolecular assembly of chloroauric acid as an oxidant [15]. The formation of nanorods and microspheres of PIn conducting polymer based on chemical synthesis using two miscible and two immiscible solvents respectively without surfactant and supported by UV-vis spectrum [16]. Joshi et al. focused on indole polymerization governed by chloro-auric acid also reduction of Au^{3+} ions occurred simultaneously in a single step, was monitored using UV-vis absorption spectroscopy [17]. There are various techniques of polymerization, but chemical polymerization is

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easier than other techniques. The synthesis of conducting polymers through chemical oxidative polymerization route offers mass production at sensible cost.

This research article is intended by presenting a more systematic report on the novel complex optical study of as-synthesized PIn through chemical route using oxidant $FeCl_3$ at room temperature. From the literature of materials science, not a single report present on the complex optical study of PIn synthesized using an oxidant $FeCl_3$. The as-synthesized materials were characterized through X-ray diffraction (XRD), field emission scanning electron microscope (FE-SEM) analysis, and ultra violet-visible (UV-vis) spectroscopy.

2. Experimental

2.1. Materials

All chemicals, such as monomer indole, oxidant anhydrous iron (III) chloride ($FeCl_3$), hydrogen peroxide (H_2O_2) used as catalyst, were of analytical grade and procured from SD Fine Chemicals, India. The indole monomer was used as received for synthesis of PIn without further purification. The polymeric materials were prepared via chemical oxidative technique using $FeCl_3$ as an oxidant. In the typical procedure, monomer and oxidant in stiochometric ratio were dissolved in deionized water. Consequently, H_2O_2 (0.1 M) was added into the reaction mixture, which wont to enhance the rate of reaction and conjointly yield. The reaction mixture was allowed for constant stirring for 12 h to complete polymerization reaction with a magnetic stirrer at 30 °C. The precipitate was washed with copious amounts of triply distilled water until the washings were clear and then kept for overnight at room temperature. Subsequent to this step, sample was sintered at 60 °C for 30 min. By adopting same route, successful synthesis of five samples of different wt. % was carried out.

3. Results and discussion

The XRD pattern of powder sample was recorded on Rigaku miniflex-II X-ray diffraction using CuKα radiation (λ = 1.54 Å) in the range 10°–70°. The XRD pattern for PIn powder sample with 0.6 M of $FeCl_3$ is depicted in Fig. 1. The pattern shows the broad hump appears at 2θ region of 18–28° and absence of well-defined peaks clearly pointed out that the as-synthesized material is purely amorphous.

The morphology and structural features of the material studied by FE-SEM (JEOL JSM-6360). The surface morphology of PIn powder sample with 0.6 M of $FeCl_3$ was analyzed by FE-SEM and the micrograph is displayed in Fig. 2. The FE-SEM micrograph represents the macro-granular structure formed by the aggregation of small globular structures. The nature of particles has irregular in structure which reflects definite amorphous morphology. The micrograph depicts the presence of aggregation up to some extent as well as an agglomeration of particles.

In order to study the complex optical properties of as-synthesized PIn materials, the UV-vis spectroscopic analysis were carried out through Agilent Technologies, Cary 60 UV-vis. Fig. 3 shows UV-vis spectrum of PIn with different concentration of $FeCl_3$. To investigate the optical parameters of as-synthesized material, the analysis of the spectrum was carried out. From the plot, it is observed that, the % absorption is higher on the lower wavelength side. The spectrum of as-synthesized material exhibits absorption around the 220–300 nm. The two different absorption peaks, at 225 nm and 280 nm grew due to wide chain length distribution of polymer [18].

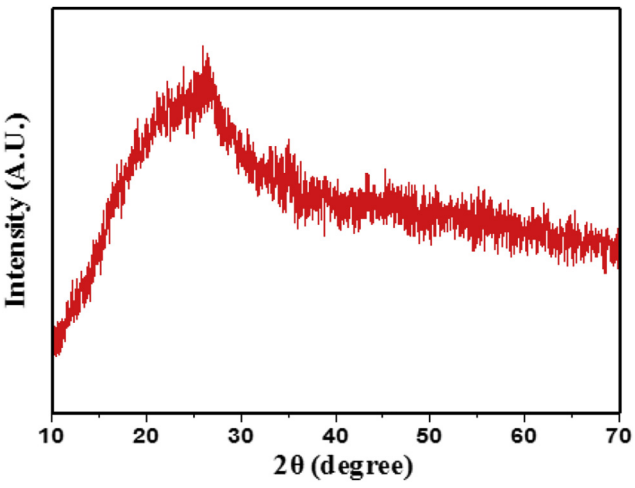

Fig. 1 – XRD pattern of PIn sample with 0.6 M of $FeCl_3$.

The optical band gap of PIn (0.3–0.7 M of $FeCl_3$) was calculated by using the plot between αhν and photon energy hν (eV) as depicted in Fig. 4 (a–e). The material has many applications depend upon its optical band gap. The relation between absorption coefficient (α) and incident photon energy (hν) can be expressed as in Equation (1) [19–21];

$$\alpha = \frac{A(h\nu - Eg)^n}{h\nu} \quad (1)$$

where, A is constant and Eg is optical band gap of material.

The values of the optical band gap of PIn with different concentration of $FeCl_3$ have been determined in the energy range 4.630–5.224 eV. The optical band gap energy values obviously concluded that, this material has potential

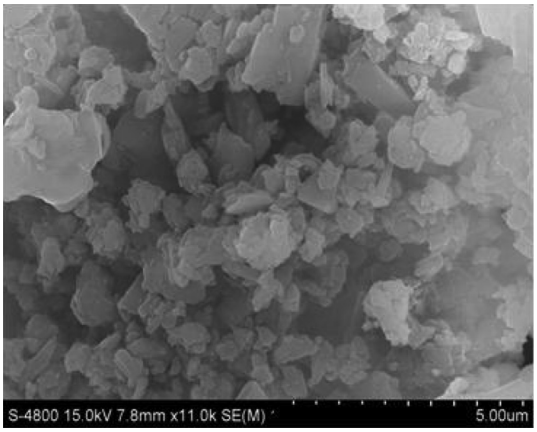

Fig. 2 – FE-SEM micrograph of PIn with 0.6 M of $FeCl_3$.