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Electrochemical Polymerization and Characterization of Multipurpose Advanced Polymers

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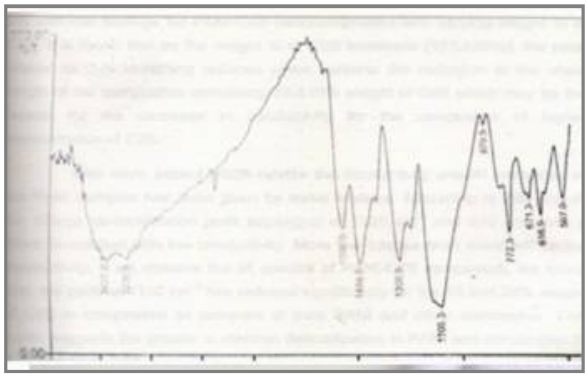
ABSTRACT

The speedy development of the polymer industry with balanced properties for industrial applications is a matter of much interest amongst material scientists and engineers. Nano composites are possible materials than micro composites and monolithic due to their outstanding properties. This work emphasized on electrochemical polymerization of conducting polymer in presence of oxidant using inorganic compound as dopant. The synthesized polymer was characterized using different techniques. These synthesized polymers were studied for their absorption spectra and their electrical conductivities. The molecular and banding behaviour have been studied using FTIR where as conductivity measurement has been carried out by four-probe technique. It is observed that results are in comparable with the available results. The results reveals that these materials are ideally suited for the manufacture of optoelectronic devices in the visible wavelength and could also be used to photovoltaic applications such as solar cell fabrication and gas sensors etc.

Graphical Abstract



FTIR Spectra of polymer.

Keywords: Nano-composites, Electrochemical Polymerization, FTIR Technique, Electrical Conductivity, Solar cell, Optoelectronic devices etc.

INTRODUCTION

Conducting polymers provide tremendous scope for turning of their electrical conductivity from semiconducting to metallic regime. The conductivity of the conducting polymer as stated earlier can be tuned by electrical manipulation of the polymer backbone by the nature of dopant, by the degree of doping, by blending with other polymers (copolymer), by making composites with inorganic materials[**1**].When conducting polymers are taken in the composite form their properties are altered from those of basic materials. The dispersant /matrix interactions and physical properties of the matrix influence the agglomeration of the dispersant phase which affects the properties of the composites. Polymer nano-composites are polymer matrix composites in which the filler is less than 100 nm at least in one dimension. These composites exhibit extraordinary interesting properties [**2**]. A defining feature of polymer nano-composites is that the small size of the filler leads to a dramatic increase in the interfacial area creates a significant volume fraction of interfacial polymer with properties different from the bulk polymer even at low loadings. In the last 10 years new fillers have emerged providing an opportunity for the development of high performance multifunctional nano-composites. For example, transparent conducting polymer/ nanotube composites are under development as solar cell electrode, nano-particles filled amorphous polymers are being used as scratch resistance, transparent coating in cell phone and compact disc technology [**1, 3, 4**]. The recent resurgence of interest in conducting polymer nano-composites has emerged for several reasons as the size of silicon nano particles decreases, the band gap changes and the colour of particles changes. A large number of investigations have been carried out on conducting polymers due to their properties and synthesis. The material used in this work is polyaniline due to its high performance electrical property and low resistivity [**5, 6**]. Thus in this piece of paper, we have selected polyaniline as the efficient material for the industrial need due to their electrical conductivity and molecular behaviour.

MATERIALS AND METHODS

We have used all chemicals obtained from E-Merck Chemical Company of Research grade. A numbers of methods have been reported for the preparation of nano composites. For the commercial production of nanopowders, the following methods are used.

1. Sol-gel method.
2. Gas condensation processing.
3. Chemical vapour condensation.
4. Pulsed Laser Method.
5. Liquid solid method. (precipitation method)
6. Electro Chemical Polymerization

Synthesis of ZnS nano-particles is one of the compounds which has wide ranging applications in solar cells, infrared window materials, photo-diode and cathode ray tube, electroluminescent devices and multilayer dielectric filters. ZnS occurs in two crystalline forms, one in the hexagonal system and the other in cubic system. The minerals in hexagonal system are called Wurtzites where as the cubic system as zinc blended and is insoluble in water. The physical properties of ZnS are white to grey-white or apple yellow powder.

Polyaniline is synthesised by chemical oxidation method. In which 100 mL solution of aniline is added in 1 M sulphuric acid and the 0.5M solution of ammonium per sulphate was added drop wise with constant stirring at room temperature at normal condition. The resulting solution is filtered, washed with distilled water and sulphuric acid until the filtrate become colourless and finally the removes the impurities. The solution is chemically polymerised and dried in vacuum. Finally grinded and the product is obtained in the form of greenish black salt. The electrochemical polymerization of polyaniline is carried out in presence of sulphuric acid in the polymerization vessel at different

voltages [6]. We have also prepared the aniline solution by chemical oxidation method for characterization and conductivity measurement.

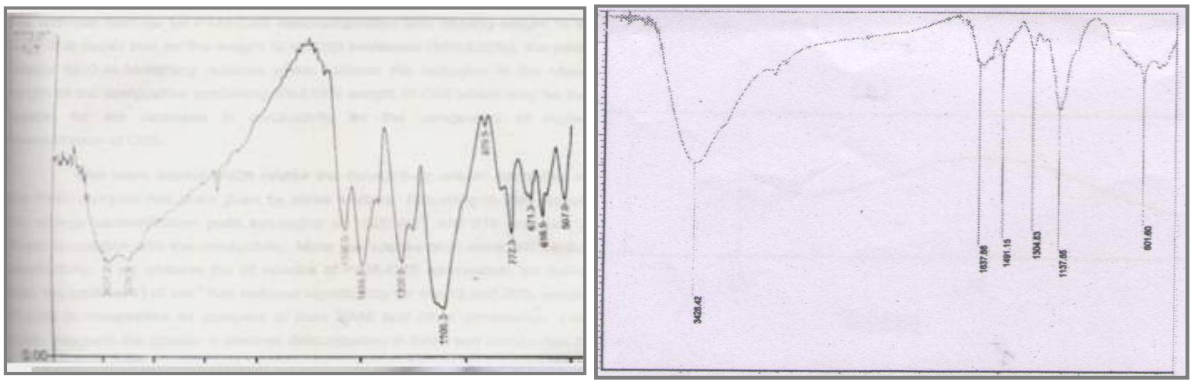
Characterization: The synthesized powder form material by different techniques is characterized using FTIR spectroscopy available in our lab and the spectrum is shown as figure 1(a) and 1(b) respectively where as electrical resistance measurement is done by four-probe method. It is observed that the electrical resistance (R) is related with the electrical conductivity (C) as-

$$C = \frac{1}{K.R.D}$$

Where, { K.R} is sheet resistance, D is the thickness of pellet and K is a constant equal to $\left(\frac{\pi}{ln2}\right)$ [7].

RESULTS AND DISCUSSION

FTIR spectroscopy: The FTIR Spectra of synthesized polymer by different techniques has been given at figure 1(a) and 1(b). A view of these spectra insists that the band observed at 2922.52 cm^{-1}, 2922.19 cm^{-1} are due to asymmetric C-H stretching and 2818.16 cm^{-1} is due to symmetric C-H vibration. The absorption band obtained between 1210 To 1280 cm^{-1} indicates stretching of primary amines. The absorption bands lies below 1000 cm^{-1} are the characteristic of mono substitute benzene. Our findings are comparable to the other co-workers [7, 9]. The observed FTIR Spectra also indicates that the certain peaks are due to complete polymerization. It is also observed that the C-N stretching band of an aromatic amine appeared at 1300 cm^{-1}. These bands are well matched with the spectra of others workers when polyaniline is doped with sulphuric acid. The intensity of C-N stretching band appeared at 1300 cm^{-1} indicates the chain length of polyaniline. The change in the intensity of these bands can be observed by the addition of different dopant and the change in polymerization condition. Certain peaks in these spectrums confirm the conducting phase of the polyaniline. These characteristics are very much favouring the solar cell fabrication. It is also noticed that electrochemical polymerization method is most suited one for selecting the material for photovoltaic applications.



(a) (b)

Figure 1. FTIR Spectra of polymer.

Electrical Conductivity: The electrical conductivity of the synthesized material is measured by four-probe technique at different voltages and the conductivity is also computed by different other methods using established relation [9]. It is observed that the electrical conductivity of the synthesized material through electro chemical polymerisation is higher than the materials synthesized by any other methods [7]. It is also noted that the conductivity of the material increases as the voltage of pellets increases.

APPLICATION

The conducting polymers have the photo voltaic applications. Due to high performance of electrical properties the polyaniline synthesized through electro polymerisation has a vast application in the rechargeable battery, solar cell techniques and can also be used for materials of LED's as well as transparent coating in cell phones. This material can also be used in optoelectronic devices [**10**].

CONCLUSION

The analysis of FTIR Spectra confirms the chemical structure of polyaniline. It is also observed that there is a change is the corresponding frequencies of polymer but no major change was observed between the composites with the increase of nano filters. It is also concluded that the peak intensities in IR spectra and conductivity version in the polymers are in tight integration with each other. The conductivity measurement of the synthesized material through electro-chemical polymerization is higher than the conductivity of sample by any other process and it is noticed that the conductivity increases by increasing voltage. Thus these materials are highly suited for optoelectronic devices and solar cell fabrication.

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