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Lithium Nickelate Dispersed Polyvinyl Alcohol Nanocomposite Film: Structure, Morphology and Bonding

KEYWORDS Nanocomposite, Nanomaterials, Lithium Nickelate, XRD, SEM, IR

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ABSTRACT *The polymer composite materials are prepared by incorporation of nanomaterials in to polymer matrix, which improves the properties and applications of polymers. Fine dispersion of nanomaterials in to polymer matrix selectively responses the formation of polymer nanocomposite film. A simple solvent casting method for the synthesis of lithium nickelate dispersed polyvinyl alcohol (PVA) nanocomposites is reported. X-ray diffraction (XRD) technique is used to know the structural arrangement nanocomposites. This study reveals the development of crystallinity in amorphous polyvinyl alcohol The morphological study is undertaken by scanning electron micrograph (SEM) tool. The applicable morphology can observe in PVA nanocomposites. The bonding nature in the composite materials is observed by Infrared(IR) tool.*

INTRODUCTION

Nano sized inorganic materials like metal oxides filled polymers constitute a new class of polymer nanocomposite materials [1-2]. These nanocomposite materials exhibit markedly improved properties when compared to the pure polymers or their traditional composites, because of their nanometer sizes [3-4]. Conventionally filled polymers attracted researchers due its high thermal stability and heat resistant property. Several attempts are made to enhance the desired properties of polymers by preparing its nanocopmosites. The extension of their utility by reinforcing them with nanoscale materials to drive improved properties [5-6].

Inorganic particles of size typically 10-100nm dispersed in an organic polymer matrix construct nanstructured materials [7]. Nanocomposite materials based on nanosized inorganic materials have been of great interest to researchers due to their applications[8-9]. Metal oxides dispersed polymer nanocomposites have been extensively studied since they exhibit interesting properties with many applications such as quantum electronic devices, magnetic recording materials, sensors, capacitors, smart windows, toners in photocopying, conducting paints and rechargeable batteries [10-14]. These composites are often prepared by dispersing nanomaterials in a non-conducting polymer matrix [15]. The present investigation is the lithium nickelate dispersed polyvinyl alcohol (PVA) nanocomposite film, which is prepared by dispersing lithium nickelate nanomaterials in to PVA matrix through solvent casting method. The as prepared composite films were characterized by different characterization techniques.

EXPERIMENTAL

Materials and methods

Polyvinyl alcohol of molecular weight 125,000 was obtained commercially. Double distilled water is used as a solvent for preparation of nanocomposite material. Solvent casting method is adopted for the synthesis of cobalt oxide nanoparticles dispersed polyvinyl alcohol nanocomposite film.

Synthesis of Polyvinyl alcohol-Lithium Nickelate (PVA-$LiNiO_2$) nanocomposite film.

In our earlier work, we reported the synthesis of lithium nickelate nanoparticles through thermal decomposition of lithium oxide and nickel oxide [16]. PVA-$LiNiO_2$ nanocomposte film was prepared by solvent casting method. A known weight (2.0 gm) of PVA is dissolved in water and stir well for polymer gel. This gel solution was then transferred to vacuum rotary evaporator for casting the solvent. Known quantity (0.1gm) of as prepared $LiNiO_2$ (10wt %) was sonicated for 12 hours in separate containers. The above sonicated cobalt oxide were mixed with PVA gel solution in a rotary evaporator which was constantly maintained at 80-90 ^{0}C in a water bath. The solvent was evaporated slowly by applying the vacuum with a rotation of 200 rpm/min. A uniform lithium nickelate dispersed PVA film is obtained. As prepared film is free from air bubbles and form uniformly lithium nickelate dispersed polyvinyl alcohol nanocomposite film. The optical micrograph image of as prepared nanocomposite film is shown in figure 1. One can observe fine dispersion of nano oxide material in the polymer matrix. This nanocomposite film is characterized by characterization techniques and thermal behavior is studied by thermal technique.

Figure1: Optical image of PVA-$LiNiO_2$ nanocomposite

Characterization

The powder X-ray diffraction pattern of cobalt oxide dispersed polyvinyl alcohol nanocomposite film was obtained from GEOL JDX-8P X-ray diffractometer using CoKα radiation. The morphology of the nanocomposite film was obtained from Leica Cambridge-440 scanning electron microscope. The infrared spectrum of PVA composite was

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recorded on a Perkin-Elmer FTIR spectrometer [model 100] in the range 4000-300cm^{-1}.

RESULTS AND DISCUSSION

X-ray diffraction

In our ealier study we report that the XRD pattern does not shows any Bragg's reflections indicates the amorphous nature. Figure 2 shows the XRD pattern of $LiNiO_2$ dispersed PVA nanocomposite film. The pattern shows the presence of lithium nickelate reflections and are indexed as "M" in the pattern by the reference of its JCPDS file #09-0063. The oxide peaks in the composite pattern confirm the formation of PVA-$LiNiO_2$ composite and development of crystallinity in the amorphous PVA matrix. The sharp intensity peaks are found in the PVA nanocomposite films shows the development of crystallinity in the amorphous PVA matrix. Formation of crystallinity in PVA matrix is due to the complexation of oxide nanomaterials with PVA matrix. A comparison of the X-ray diffraction pattern of pure PVA with its PVA nanocomposites shows that the diffraction peaks in the composite pattern is due to development of crystallinity in the amorphous polyvinyl alcohol.

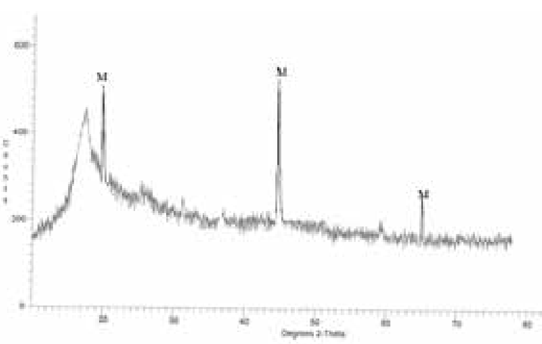

Figure 2: XRD pattern of PVA-$LiNiO_2$ nanocomposite

Scanning Electron Micrograph

Figure 3 shows the SEM image of PVA-$LiNiO_2$ nanocomposite film. Dispersion and dispersed phases are observed in polyvinyl alcohol-oxide matrix composite. Irregular shaped particles with particle agglomeration can also be viewed. Some streaks of polyvinyl alcohol with a widening in dimension is observed. One can find applicable morphology of this composite film.

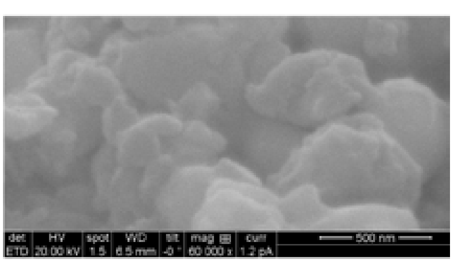

Figure 3: SEM image of $LiNiO_2$ dispersed PVA nanocomposite film.

FTIR studies

In our earlier report, we have reported FTIR of pure polyvinyl alcohol [17]. Figure 4 shows FTIR spectrum of PVA-$LiNiO_2$ composite sample. Some additional peaks and shift in the vibrational frequencies in the PVA composite spectrum in comparison with of pure PVA is observed, which confirms the formation of PVA composite. These additional peaks and shifts of the peaks in composite spectrum are due to the presence of inserted oxide in the PVA matrix and it may be possible due to H-type interactions between $LiNiO_2$and PVA. Characteristic peak of metal-oxygen[18] below 1000 cm^{-1} have disappeared in the composite spectrum due to PVA masking of lithium nickalate particles.

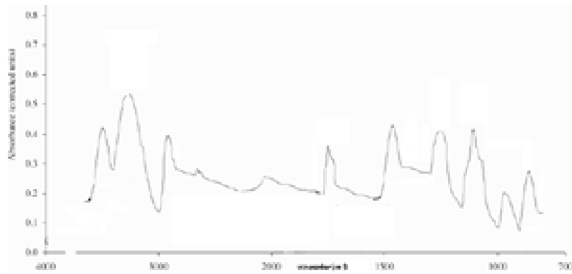

Figure 4: FTIR spectrum of PVA-$LiNiO_2$ nanocomposite film.

CONCLUSIONS

Possible uniform dispertion of lithium nickelate nanoparticles in to the polyvinyl alcohol matrix takes place with the help of solvent casting method. This method is known for its simplicity and requires less experimentation. Crystallinity in the polymer may developed by incorporation of lithium nickelate in to polymer matrix. Morphological study represents the change in morphology with addition of nanoscopic inorganic materials to polymers. Additional reflections and shifted frequency in the FTIR study is observed in PVA composite compared to its pure PVA. Preparation of different polyvinyl alcohol nanocomposites with different fibrous materials is our future direction of work

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