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Optical, Thermal and Fluorescence Properties of Spin-Coated Solid Polymer Electrolyte Films

Sharanappa Chapi and Devendrappa H*

[a]*Department of Physics, Mangalore University Mangalagangothri – 574 199, INDIA*

Abstract

Polyethylene oxide (PEO) −Polyvinylpyrrolidone (PVP) blended (50/50) filled with different concentration of Co^{2+} ions were prepared by spin-coating method. The films were characterized by UV-Absorption, TG/DTA, SEM and Fluorescence techniques. From the UV-Vis absorption results shows that optical band gap found decreases with increase cobalt ions content, this indicates that there are electrons inter band transition taken place. The thermal stability of the polymer blend has improved after filling $CoCl_2$ increases; this indicates that the filler acts as a plasticizer. In particular, remarkable enhancement of the fluorescence properties of $CoCl_2$ doped polymer blend was observed in different excitation light from 350 to 476 nm. The linear optical constants such as the extinction coefficient (k), refractive index (n), real (ε_r) and imaginary (ε_i) dielectric constant, optical conductivity (σ_{opt}) are calculated. The optical properties i.e., good photostability and larger stokes shift suggesting, in order to evaluate their potentialities for their use in electrochemical display device applications.

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Keywords: Polymer blend; Optical properties; Dielectric constant; SEM; Fluorescence; Thermal stebility.

* Corresponding author. Tel.: (+91)-0824-2888707; Fax: (+91)-0824-2287289.
E-mail address: dehu2010@gmail.com

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1. Introduction

Solid polymer electrolytes (SPEs) complexes formed between ionic salt and polymer through electron-donor atoms such as poly (ethylene oxide) (PEO) [1, 2]. SPEs have been found to have a great deal of advantages in replacing conventional liquid electrolytes and others. These advantages include high specific energy, high energy density, high ionic conductivity, wide electrochemical stability windows, light, solvent free condition and easy processability. The main advantages of polymer electrolytes are their favourable electrical, optical and mechanical properties, ease of fabrication in thin film form and ability to form effective electrode-electrolyte contacts [3].

In addition flexibility of fabricating over a large area of substrate from its solution by simple processing techniques such as sol-gel, spin-coating, solvent casting, sublimation, dip coating. Spin coating technique was used in this study because it would allow the thin film production of large area films with easy intentional doping. Spin coating is widely used for producing thin polymer films with a homogeneous thickness. A typical process involves depositing a polymer solution onto a solid substrate and then start rotating the substrate at high speed. Due to the spinning, the solvent evaporates and a residual solid polymer film covers the substrates.Blending of different polymers provides easy preparation and feasible control of the physical properties within the miscibility compositional region. It also exhibits properties that are superior to the properties of individual component of the blend [4–6].

Recently, PEO and PVP blend based polymer electrolytes with sodium fluoride (NaF) has reported by *Kirankumar et al*., [7]. To the best of authors' knowledge, no work has been reported on PEO/PVP/$CoCl_2$ based polymer blend electrolytes. Hence, the PEO and PVP with $CoCl_2$ salt in the present work to achieve higher optical conductivity because cobalt chloride remains a common choice of guest salt. In this investigation, the host polymer is PEO because it is the most interesting base material and it has high chemical, thermal and environmental stabilities.

PEO usually consists of a mixture of crystalline and amorphous phases, in which amorphous has significantly influences the ion transport. PVP is the conjugated polymer; it has the good environmental stability, easy process ability, thermal stability and charge transport mechanism [8]. The structural and optical parameters such as optical band gap, optical transmission, refractive index, optical conductivity and dielectric constants, etc. are an essential prerequisite to use in device applications [9].

The main goal of the present investigation is to optimize the concentration of $CoCl_2$ in PEO/PVP based solid polymer blend electrolyte by spin coating technique. The optical parameters, TG/DTA and Scanning Electron Microscope (SEM), Fluorescence techniques are used to study their optical constants, thermal and morphology of polymer blend electrolyte films.

2. Introduction

2.1. Materials

PEO (molecular weight, 5,000,000) and PVP (molecular weight, 40,000) purchased from Sigma-Aldrich (USA), Anhydrous cobalt (II) chloride ($CoCl_2.6H_2O$) salt (molecular weight, 129.839) used as a dopant from Merck (India) were used as received for the preparation of polymer electrolyte. Methanol of analytical grade having purity > 99% obtained from Merck was used as common solvent for both polymers. Films of (PEO/PVP) blend and $CoCl_2$ salt complexed (PEO/PVP/$CoCl_2$) blend were prepared in weight ratios (47.5/47.5/5) and (45/45/10) by spin coating technique. PEO and PVP were dissolved in methanol separately with continuous stirrer for 10–12 hours, both solutions were mixed and the desired amount of dopant was added to this mixture. The mixture was stirred till to obtain a homogenous viscous mixture this mixture used to spin-coat as shown in scheme 1.

2.2. Preparation of polymer blend electrolyte films by Spin Coating Method

The vacuum spin coater Model VTC-100 (Germany) onto "Blue star" (Polar industrial corporation, Mumbai) was used for blend thin film preparation. The glass substrates were cleaned by an ultrasonic alkaline bath at 313 K for 10 min followed by ultrasonic bath treatment with ultra-high purified water. Then the glass plates were first rinsed in