

Final Report of UGC Major Research Project

(F. No. 41-879/2012/SR dated 25-07-2012)
[W.E.F. September 24, 2012]

on

Study of Electrical and Optical Properties of Doped Polymer Electrolyte Film

Submitted by

Dr. DEVENDRAPPA H

Dr. Devendrappa H, Associate Professor
Department of Studies in Physics, Mangalore University
Mangalagangothri – 574 199, INDIA
E-mail:dehu2010@gmail.com



2015

Final Progress Report (Period from 24-09-2012 to 31-12-2015)

Final report of work done on the UGC-Major Research Project

Title of research project : Study of electrical and optical properties of doped polymer
Electrolyte film

UGC Reference No. : No. F. No. 41-879/2012/SR dated 25-07-2012 and
F.No. 41-879/2012/(SR) dated June 2015.

Name of the Principal Investigator: Dr. Devendrappa H, Associate Professor
Department of Studies in Physics, Mangalore University
Mangalagangothri – 574 199, INDIA
E-mail: dehu2010@gmail.com

OBJECTIVES OF THE PROJECT:

1. The preparation of polyethylene oxide with salts divalent/pentavalent salt in the different weight percentage ratios using spin coating technique.
2. Employed the characterization of films using techniques of XRD, IR, SEM and DSC techniques.
3. To study the electrical conductivity of doped films using two probe method.
4. To study the optical property of doped films and its constants.

SUMMARY OF THE FINDINGS

I. Out Come of Research Work

➤ The preparation of films using solution-casting method

- i) The Polyethylene oxide (PEO) and potassium chloride (KCl) films in various weight percentage compositions of (0%, 5%, 10%, 15%, 20%, and 25 %).
- ii) The Polyethylene oxide (PEO) and cobalt chloride ($\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$) films in various weight percentage compositions of (1%, 3%, 5%, and 10 %).

➤ The preparation of films using spin-coat method

- iii) Preparation of polymer blend electrolytes films deposited on different glass substrates like, quartz plates, ITO and Blue star glass substrates.
- iv) Preparation of polymer composites (PCs) films (PEO/PVP/ CoCl_2) by spin coat method on quartz substrate for 0, 5 and 10 wt% of dopant.

Characterizations techniques

The X-ray diffraction used to investigate the structural phase of polymer electrolyte films, the data were acquired using Rigaku miniflex 600-bench top X-ray diffractometer with $\text{CuK}\alpha$ radiation ($\lambda=1.54178 \text{ \AA}$). The FT-IR measurement was done by using Shimadzu Spectrophotometer [Model 8000] in the range of $400\text{--}4000 \text{ cm}^{-1}$. The electrical conductivity measurement was performed by using Wayne Kerr 6500B Precision impedance analyzer at different temperatures (303–343 K). POM (Polarized Optical Microscopy) Prog Res C5 in bright field and SEM (JEOL Model JSM–6390LV EDS Make JEOL Model JED–2300) characterized the surface morphology of the films. The cyclic voltammetry (CV), Chronocoulometry (CC) and AC impedance studies were carried out using the electrochemical workstation (CHI660E) with three electrode configuration, polymer electrolyte as a working electrode, platinum wire as a counter electrode and Ag/AgCl as a reference electrode

===

II. Summary

The PEO/ CoCl_2 and PEO/KCl polymer electrolytes films were confirmed from the XRD and surface morphology (SEM & POM) analysis showed that the enhancement in the volume of amorphous and reduction of crystallinity with the increase in dopant content. And it was confirmed in FT-IR result that change in intensity, shape and position of the peaks due to chemical interaction between the dopant and host polymer. The optical band gaps showed a decreasing trend with dopant.

The ionic conductivity of pure PEO is $8.60 \times 10^{-8} \text{ Scm}^{-1}$ found increased to $3.5 \times 10^{-3} \text{ Scm}^{-1}$ for 5% dopant at 303 K, it is also increases with temperature; it follows Arrhenius behaviour and the activation energy of PEO is 0.23 eV decreased to 0.064 eV for 5% dopant.

The maximum ionic conductivity $4.32 \times 10^{-6} \text{ Scm}^{-1}$ at 303K for 20wt% KCl & activation energy was decreased trend with increasing the dopant.

Transport number studies suggest that the charge transport in these polymer electrolytes is predominantly ionic because of amorphicity dominant in the films. The purity and electrochemical stability of the Co^{2+} doped PEO samples have been established based on the CV studies. Finally, it may be concluded that remarkably improved in ionic conductivity and cyclic stability by the addition of CoCl_2 salt is presumed to be considered this (PCL5) polymer

electrolyte system is a suitable candidature for solid-state battery, optoelectronic and other energy storage devices.

The PEO/PVP/CoCl₂ blend electrolytes were prepared using spin coating method. The XRD patterns of PEO/PVP/ CoCl₂ electrolytes suggest an increase in the amorphous phase with increasing CoCl₂ concentration. The UV–Vis. spectral study revealed a decrease in the optical band gaps and Urbach energy, meanwhile increase in the number of carbon atoms (*N*) per conjugated length. The highest ionic conductivity $0.651 \times 10^{-4} \text{ S cm}^{-1}$ for PEO/PVP/CoCl₂ (45/45/10) at 303 K. Attainment of smooth surface morphology upon the addition of salt also suggests the enhancement of the degree of amorphicity. The thermal stability and electrochemical performance was significantly improved may be a viable candidate for electrochemical device applications such as high-performance solid-state batteries, smart windows, microelectronics and electrochromic devices.

III. Publications details

Papers published in journals

- [1] A paper entitle “Studying the Effect of KCl Addition on the Optical Properties and Morphological of the Solid Polymer Electrolyte Film”, *International Journal of Chem Tech Research*. Vol.6, No.6, pp 3321–3324, Aug-Sep 2014. Sharanappa Chapi, Raghu S, Mini V, Archana K and Devendrappa H
- [2] A paper entitle “Influence of Cobalt (II) Chloride Catalyzed on the Thermal and Optical Characterization of PEO Based Solid Polymer Electrolytes”, *Journal of Research Updates in Polymer Science*. Vol. 3, No.4, pp 205–215, January 02, 2015. Sharanappa Chapi and Devendrappa H
- [3] A paper entitle “Structural, Optical and Thermal Study on PEO-Based Solid Polymer Electrolytes for Optical Device Application”'s (MS-Nr: masy. 201400272.R1) in its current form for publication in *Macromolecular Symposia* (Accepted)

No. of papers communicated

1. A paper entitles “**Enhanced electrochemical, structural, optical, thermal stability and ionic conductivity of (PEO/PVP) polymer blend electrolyte for electrochemical applications**” communicated to **Ionics journal (No: 2015-0486.R2 under review)**.

- [4] Ionic conductivity and electrochemical studies in cobalt chloride doped polyethylene oxide solid polymer electrolytes for solid state battery application (Communicated)

Papers published in proceedings:

- [1] Enhanced Ionic Conductivity and Optical Studies of Plasticized (PEO-KCl) Solid Polymer Electrolytes, AIP Conference Proceedings 1665, 040017 (2015); doi: 10.1063/1.4917630. Sharanappa Chapi and Devendrappa H.

Papers selected in proceedings:

- [2] A paper entitled “Synthesis and Characterization of Nanocomposite Polymer Blend Electrolyte Thin Films by Spin-Coating Method” Proceedings 60thDAE-Solid State Physics Symposium will be held at Amity University UP, Noida, Uttar Pradesh during December 21-25, 2015. Sharanappa Chapi, Niranjana M, Devendrappa H.
- [3] A paper entitled “Optical, Thermal and Fluorescence Properties of Spin-Coated Solid Polymer Electrolyte Film” participated and presented a paper in Recent Advances In Nano-Science And Technology (RAINSAT-2015) was held at Sathyabama University, India, during July 8th - 10th, 2015. Sharanappa Chapi, Devendrappa H.

International/national Conferences attended and papers presented:

- [1] A paper entitled “*Optical, Thermal and Fluorescence Properties of Spin-Coated Solid Polymer Electrolyte Film*” participated and presented a paper in Recent Advances In Nano-Science And Technology (RAINSAT-2015) was held at Sathyabama University, India, during July 8th - 10th, 2015. **Sharanappa Chapi**& Devendrappa H.
- [2] A paper entitled “*Influence of Cobalt (II) Chloride Addition on the Structural, Optical, Thermal, and Conductivity Properties of PEO Solid Polymer Electrolyte films*” participated and presented a paper “AMAN 2014” Indo-UK International Workshop On Advanced Materials and Their Applications In Nanotechnology, Birla Institute Of Technology and Science Pilani, KK Birla Goa Campus, India, From May 17–19, 2014. **Sharanappa Chapi**, Raghu S, Archana K, Mini V, Devendrappa H.
- [3] A paper entitled “*Investigate the AC Conductivity and Optical Property of Polyethylene Oxide Based Complex Films*” participated and presented a paper in ICAPM-2013 International Conference on Advanced Polymeric materials was held at MG University,

- Kottayam, Kerala. From Oct. 11-13, 2013. **Sharanappa Chapi**, Manjunatha V, Archana K, Raghu S, Subramanya K, Mini V, Devendrappa H.
- [4] A paper entitled “*Enhanced Ionic Conductivity and Optical Studies of Plastized (PEO-KCl) Solid Polymer Electrolytes*” participated and presented a paper in 59th DAE-Solid State Physics Symposium 2014 held in VIT University Vellore Tamilnadu. From Dec. 16-20, 2014. **Sharanappa Chapi** and Devendrappa H.
- [5] A paper entitled “*Studying the Effect of KCl Addition on the Optical Properties and morphological of the solid polymer electrolyte film*” participated and presented a paper in “ICMCT 2014” International Conference on Materials and Characterization techniques, held in VIT University Vellore Tamilnadu during 10-12, March 2014. **Sharanappa Chapi**, Raghu S, Subramanya K, Archana K, Mini V, Devendrappa H.
- [6] A paper entitled “*Investigate the AC Conductivity and Optical Band Gaps of in Polyethylene Oxide Based Complexes Solid Electrolyte Films*” participated and presented International Conference on Polymers: Vision & Innovations APA-2014 February 19-21, 2014, India Habitat Centre, New Delhi, India. **Sharanappa Chapi**, Raghu S, Subramanya K, Archana K, Mini V, Devendrappa H.
- [7] A paper entitled “*Conductivity and Optical Band Gaps of Polyethylene Oxide Doped with Li_2SO_4 Salt*” participated and presented a paper in 58th DAE-Solid State Physics Symposium 2013 was held at Tapar University, Punjab. From Dec. 17-21, 2013. **Sharanappa Chapi**, Raghu S, Subramanya K, Archana K, Mini V, Devendrappa H.

List of enclosures

1. Final Progress report
2. Statement of expenditures
3. Statements of incurred on field work
4. Utilization certificate
5. No. of publications out of the project
6. Requesting for HRA and Balance amount sanction letter