

Investigation of Thiophene-Based Polymer Composition Such as LED

Dr. Nitin V. Shirbhate Prof. S. V. Tambakhe Dr. S. P. Yawale

Abstract— The composition of polyvinyl acetate (PVAc) - Polythiophene (PTh) were prepared by chemical oxidative polymerization with $ZnCl_2$ as oxidant, in methanol as solvent at room temperature. The characteristics of the polymer were characterized by XRD and FTIR as well as photoluminescence. A single layer organic device was fabricated and resulted in bright stable electroluminescence at room temperature. The photoluminescence shows sharp peaks at 420 nm and 440, nm for optimized 18 wt % of thiophene corresponds to blue light emission. All of the results indicate that this polymer is used for application in light-emitting devices (LEDs).

Keywords: polymer, thiophene, optical, electrical, LED

I. INTRODUCTION

Conducting polymers, also sometimes called conjugated conducting polymers, have high electrical conductivity. Conjugated polymers have received a great deal of attention in the last decade due to their potential applications in optoelectronic devices such as organic light-emitting diodes (LEDs) [1], photovoltaic cells [2] and photo transistors [3] gas sensors [4]. A wide range of conjugated polymer systems and their derivatives have been developed, such as poly (1, 4-phenylenevinylene) (PPV) [5, 6], poly (p-phenylene) (PPP) [7], polyfluorene (PF) [8] and polythiophenes (PT) (fig.1.1) [9-11]. Among these polymers polythiophenes are being regarded as one of the most promising materials because of their good thermal and chemical stability, as well as excellent electronic and optical properties [12-15]. Many composites of polythiophene have been reported using various matrices of conventional polymers such as PTP-PolyN-Vinylcarbazole[16], PTP-Polyimide[17], PTP-Polyfuran[18].

II. METHODOLOGY

Polythiophene was synthesized at room temperature (303 K) by mixing thiophene with solution of $ZnCl_2$ and polyvinyl acetate (PVAc) [AR grade] in methanol solvent. A solution of PVAc was first prepared in methanol. The composition of the solution was PVAc: Methnol = 10:90 (wt % ratio). Concentration of $ZnCl_2$ in this solution was changed from 0.1 to 1.2. For that wt% quantity of thiophene was kept constant at 0.4 ml. Monomer thiophene was added to the solution of PVAc-methanol- $ZnCl_2$ and homogeneous solution was obtained. The solution was then poured on a chemically cleaned optically plane glass plate, to prepare the composite films. After evaporation of the solvent, the transparent thin films were formed which were then washed with water to remove the excess of $ZnCl_2$. The optimized value of $ZnCl_2$ for which we get maximum conductivity that value is then kept constant. Such other films were prepared for different wt % of thiophene varies from 5 to 40 wt. % of

polythiophene. The optimized concentration of thiophene was prepared. The optimized value of thiophene for which we get maximum conductivity that obtained value is 18 wt. % of thiophene. By keeping such concentration constant we proceed for the fabrication of LED. For the device fabrication, indium tin oxide (ITO) coated glass plates were used as substrates. The surface of indium tin oxide (ITO) was cleaned by using acetone and dried it. The layer of optimized polythiophene (PTh) composition was coated on it. Finally Aluminium (Al) sheet is deposited on the polythiophene and electrodes are attached at the one end of ITO surface and other to polythiophene , as shown in following fig.1

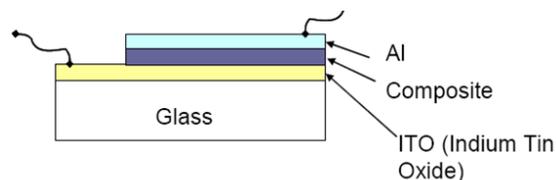


Fig.1: - Schematic of a polymer LED

III. RESULTS

Each curve shows the peaks at the same diffraction angle 2θ indicates same phase formation or crystallite occurs in the present sample, which are due to $ZnCl_2$. The percent crystallinity is calculated and found to near about 5% in all samples. The percent crystallinity is found to be negligible as compared to the amorphous state hence the overall behavior in the properties is due to amorphous nature. The peaks found in X-Ray spectra at a different angle corresponds to 'd' values are related to the $ZnCl_2$ phase. The peak observed at $2\theta = 11.330$ clearly shows the variation in the concentration of composite films. The X-RD spectra for optimized wt. % of thiophene are as shown in following figure2.

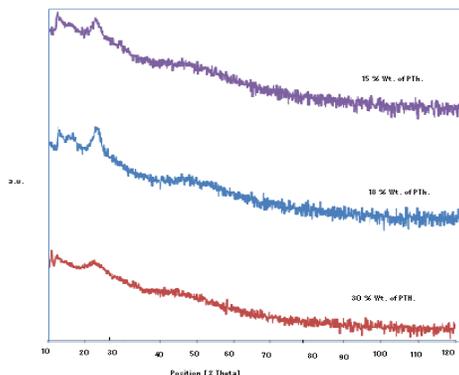
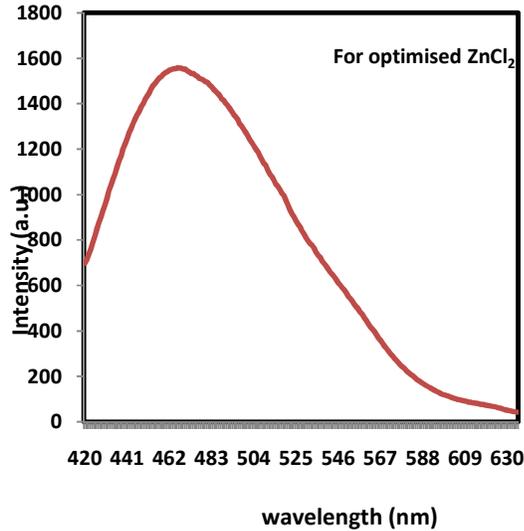
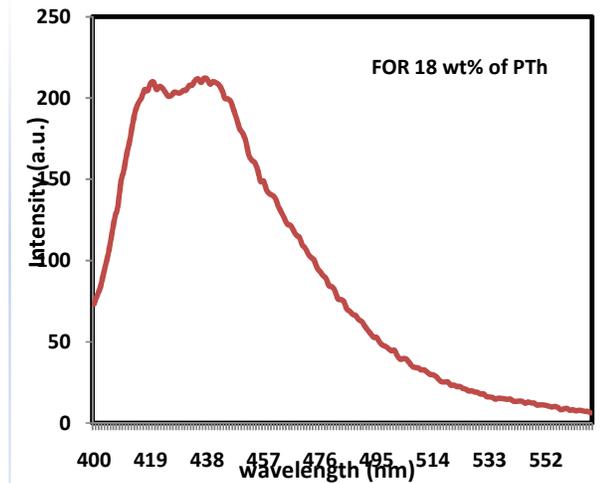


Fig2.: X-Ray diffraction pattern of PTh-PVAc films 18 wt.

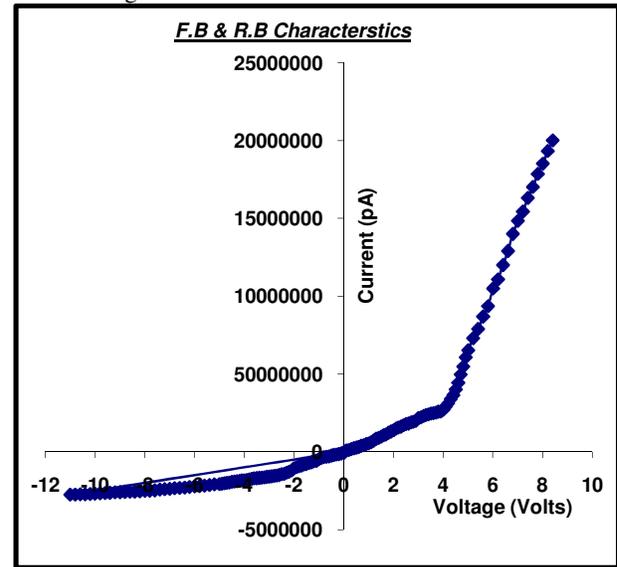
% of polythiophene

The films have been evaluated these polymers using the photoluminescence for full length of the whole visible spectrum and found that these devices emitted in the blue light. The photoluminescence characteristics of optimized $ZnCl_2$ films and optimized wt % of thiophene films are as shown in figure3 and 4.


Fig.3-Photoluminescence spectra for optimised value of $ZnCl_2$.

Fig.4-Photoluminescence spectra for 18 wt % of thiophene.

The photoluminescence shows sharp peaks at 420, 425, 440, 445 nm for optimized wt % of thiophene and $ZnCl_2$ corresponds to blue light emission.

The forward bias and reverse bias V/I characteristics of the optimized wt % of thiophene sample is as shown in figure 5.


Fig.5-V-I characteristics of optimized wt. % of thiophene sample

IV. DISCUSSION

Polythiophene (PTh)-Polyvinyl acetate (PVAc) composite is studied. The X-ray diffraction technique has been used to check the amorphous nature of the sample. It is known that the absence of peak in the intensity versus 2θ curve represents complete amorphous state of the sample. Short range order peaks are observed in few samples, from which the percent crystallinity is calculated and found to be negligible as compared to the amorphous state hence over all behavior in the properties is due to amorphous nature.

Photoluminescence Characterization techniques discussed in the following sections are those used to examine the optical properties of conjugated polymers. These characterization tools are important for understanding the role of the chemical structure or the properties of these materials. The photoluminescence shows sharp peaks at 420, 425, 440 and 445 nm corresponds to blue light emission. LED structure using ITO coated glass is designed and the V-I characteristics is studied. The shape of the characteristics is similar to the V-I characteristics of pn-junction diode.

From V-I characteristics it is observed that as the forward voltage increases then initially a current is zero upto certain applied voltage, further increase in the voltage heavy current flows through the structure. This voltage at which current is flowing through diode and LED just glows, that voltage is known as striking potential (V_0).

As the reverse voltage increases the current is very small and shows the reverse characteristics nature as in ordinary diode.

V. CONCLUSION

A Blue light emitting thiophene-based polymer has been synthesized and characterized. The polymer is well processable from a number of solvents and may be easily synthesized. We have presented preliminary results of studies on optical and electrical properties. Emission around 450 nm has been observed for such modified polymer insolution, as well as for spin coated layers, and an energy band gap of about 3eV was deduced from the absorption data. A successful electroluminescent device based on a single organic layer was achieved, and work is in progress for a quantitative evaluation of its efficiency. Although preliminary, these results are very interesting in view of the potential applications of thiophene-based polymers in the realization of single layer organic devices and even more complex device structures.

We believe that thiophenic monomer presented here demonstrates promising qualities for future use in organic LED applications

REFERENCES

- [1] A. J. Heeger, *Angew. Chem. Int. Ed. Engl.* 40, (2001), 2591.
- [2] J. Kido and Y. Lizumi, *Appl. Phys. Lett.* 73, (1998), 2721.
- [3] R. H. Friend, R. W. Gymer, A. B. Holmes, J. H. Burroughes, R. N. Marks, C. Taliani, D. D. C. Bradley, D. A. Dos Santos, J. L. Bredas, M. Logdlund, W. R. Salaneck, *Nature* 397, (1999), 121.
- [4] S.A.Waghuley,S.P.Yawale,& S.V.Pakade(Yawale),*Optoelectronics and Advanced materials-Rapid Communications*,4, (2010),97-101
- [5] C. J. Brabec, N. S. Sariciftci and J. C. Hummelen, *Adv. Func. Mat.* 11, (2001), 15.
- [6] N. Stutzmann, R. H. Friend and H. Sirringhaus, *Science* 299, (2003), 1881.
- [7] J. H. Burroughes, D. D. C. Bradley, A. R. Brown, R. N. Marks, K. Mackay, R. H. Friend, P. L. Burn and A. B. Holmes, *Nature* 347, (1990),539.
- [8] J. Davenas, M. Chouiki, S. Besbes, A. Ltajef, H. Ben Ouada, A. Bouazizi, H.Trad and M. Majdoub, *Synth. Metals* 139, (2003), 617.
- [9] G. Grem, G. Leditzky, B. Ullrich and G. Leising, *Adv. Mater.* 4, (1992), 36.
- [10]R.S.Boble et.al, *Journal of Non-crystalline solids*, 355, (2009), 2410-2414.
- [11]W.S.Barde et.al, *Journal of Non-crystalline solids*, (2007), 1016.
- [12] Y. Ohmori, M. Uchida, K. Muro, and K. Yoshino, *Jpn. J. Appl. Phys.* 30, (1991),1941
- [13] J. Roncali, *J. Chem. Rev.* 92, (1992), 711.
- [14] G. Gigli, M. Anni, M. Theander, R. Cingolani, G. Barbarella, L. Favaretto and O. Inganäs, *Synthetic Metals* 119, (2001),581.
- [15] M. R. Andersson, M. Berggren, O. Inganäs, G. Gustafsson, J.-C. Gustafsson-Carlberg, D. Selse, T. Hjertberg and O. Wennerström, *Macromolecules* 28, (1995), 7525
- [16] N. Ballav and M. Biswas, *Synth. Met.* 132, (2003), 213-218.
- [17] Fengxiang Zhang and M.P. Srinivasan , *Thin Solid Films* 479,(2005), 95-102.
- [18] Nirmalya Ballav and Mukul Biswas , *Polym Int.* 54 , (2005), 725-729.