Flexible Organic Battery Technology Applied in OLED

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ABSTRACT

The development of Flexible Organic Battery Technology applied in Organic Light Emitting Diode (OLED), using an flexible optically transparent substrate material and organic semiconductor materials, has been widely utilized by the electronic industry when producing new technological products. The Organic Battery are the base Polyaniline, PANI, Lithium Perchlorate, $LiClO_4$, and Polymethylmethacrylate, PMMA, were deposited in Indium Tin Oxide, ITO, and characterized by UV-Visible Spectroscopy (UV-Vis), Electrical Parameters (EP) and Scanning Electron Microscopy (SEM). In addition, the thin film obtained by the deposition of PANI, prepared in perchloric acid solution, was identified through PANI-X1. The result obtained by UV-Vis has demonstrated that the PVDC/ITO/PANI-X1 layer does not have displacement of absorption for wavelengths greaters after spin-coating and electrodeposition. Also, both electrodes have been united by an electrolyte solution prepared with Lithium Perchlorate, $LiClO_4$, and Polymethylmethacrylate, PMMA. Thus, the result obtained through electrical measurements has demonstrated that the flexible organic battery presented the characteristic curve of standard battery after spin-coating and electrodeposition. Accordingly, the results obtained with optical and electrical characterization have revealed that the flexible organic battery demonstrated some change in optical absorption, when subjected to a many of charge and electric discharge. Moreover, the inclusion of the PANI-X1 layer reduced the effects of degradation that this charge and electric discharge caused. Studies on Scanning Electron Microscopy (SEM) have found out that the surface of PANI-X1 layers can be strongly conditioned by the surface morphology of the dielectric.

Keywords: Battery; PVDC; PANI-X1; ITO; $LiClO_4$.

1. INTRODUCTION

The synthesis and application of new nanostructured organic materials, for the development of technology based on organic devices, have taken great interest from the scientific community [1]. Research studies, realized to synthesize and characterize the components of this new class of materials, have been currently passing through a continuous process of technological advance in search of new conductive polymers. In addition, the greatest interest in studying organic semiconductor materials has been present in its potential applications, among which are: batteries, gas sensors, electrochromic devices, capacitors, electrochemical cells, organic solar cells, organic light emitting diodes (OLED), shielding of electromagnetic radiation, artificial muscles, passivation of integrated circuits MOSFET, pn junction, satellites weighing less than 0.2 kg, and others [2][3].

Thin films made of organic semiconductor materials have drawn the attention of research groups, due to its enormous potential for its application in various industries as well as the impact their results can give to technological development. Moreover, the characterization and application of new techniques for the deposition of organic semiconductor materials has been the main focus of a large number of studies, being, thus, essential in reducing production costs [4][5].

Furthermore, Flexible Organic Battery can be utilized for large and small electric devices and in many consumer products. Organics Batteries are electronic devices made by placing a thin film of an semiconductor organic material between two electrodes with different work functions. Flexible organic battery contains an electrolyte dissolved that flows through an organic electrochemical cell that reversibly converts chemical energy directly to electricity [6][7].

This research aims to develop thin films semiconductor organic material for batteries, by using the Electrodeposition technique, and characterizing the layers and devices utilizing UV-Visible Spectroscopy

(UV-Vis), Electrical Parameters (OP) and Scanning Electron Microscopy (SEM) techniques.

2. EXPERIMENTAL DETAILS

The Flexible Organic Battery, developed in this research, has been manufactured by utilizing flexible optically transparent material, covered by a layer of ITO, with 200 nm thick. The ITO has high conductivity and transmittance in the visible region of the electromagnetic spectrum, which enables their utilization, for instance, in batteries, organic gas sensors, organic transistors and electrochromic devices [8][9]. The PANI-X1 layer was deposited through the Electrodeposition system in solution prepared with perchloric acid ($HClO_4$), applying voltage of 10.0 volts, for 5 minutes, and resulting on an active layer of PANI-X1, with thickness between 180 nm and 220 nm. Both devices have been united by an electrolyte solution, prepared with Lithium Perchlorate, $LiClO_4$, and Polymethylmethacrylate, PMMA.

The developed Flexible Organic Battery device has presented a PVDC/ITO/PANI-X1/$LiClO_4$/PC/PMMA/ ITO/PVDC configuration layered, as represented schematically in figure 1.

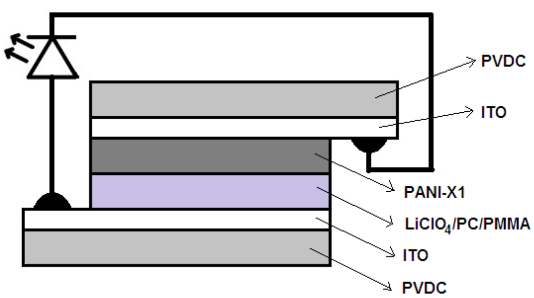

Figure 1. The Configuration of the Organic Battery.

3. DISCUSSION

The analysis of a sample through the ultraviolet-visible spectroscopy has been the result in a spectrum of light, obtained by a graph of wavelength, or frequency versus the intensity of absorption (absorbance or transmittance) [10] [11]. The absorption spectrum in the spectral region of 200-1100 nm, of the flexible organic battery, has been shown in figure 2. This result has indicated that there is no increase in the absorbance with the spin-coating technique of organic materials and with the Electrodeposition technique of organic materials.

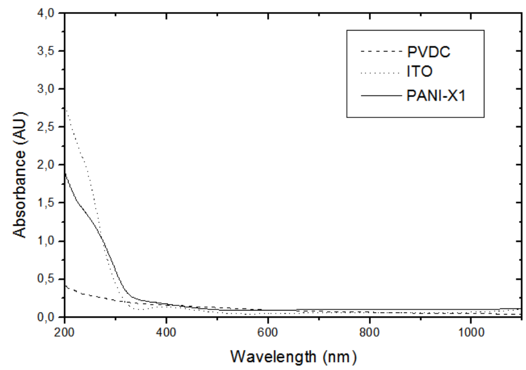

Figure 2. UV-Vis Spectroscopy of Organic Battery.

The electrical characterization of the flexible organic battery device has been carried out at room temperature, by utilizing an Electrometer Keithley 6517A semiconductor parameter analyzer. All measurements were realized without vacuum and no precautions were taken to prevent the degradation of multilayer polymeric films [5][6].

Figures 3 and 4 have demonstrated the results obtained in the electrical measurements for electrodes PVDC/ITO/PANI-X1 and $LiClO_4$/PC/PMMA/ITO/ PVDC. It is interesting to note that there has been not only an increasing in the electrical resistance, R_s, but also in the electrical resistivity, ρ, after the deposition of thin film layers. The electrical resistivity has been calculated through equation 1, where V is the voltage in volts, I is the electric current, ρ is the electrical resistivity and Δx is the thickness of the deposited material [7]. See equation 1.

$$R_s = \frac{\rho}{\Delta x} = \left(\frac{\pi}{\ell n 2}\right).\frac{V}{I} \qquad (1)$$

These graphs have indicated that the electrical resistivity has been completely related to sheet resistance and thickness, Δx, of the deposited thin film. In addition, counting on the linear fit of the experimental results through equation 2, it is possible to obtain the conductive layer of the deposited thin film, α, and the lowest resistivity, B_{res}, being associated with the gap between the valence band and the conduction band [8][9]. See equation 2.

$$\rho = \alpha . R_s + B_{res} \qquad (2)$$

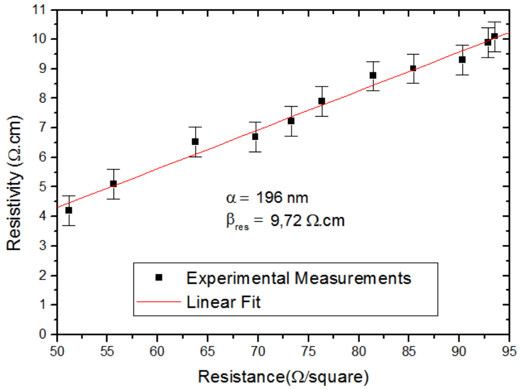

Figure 3. Electrical resistivity of the PVDC/ITO/ PANI-X1in function of sheet resistance.

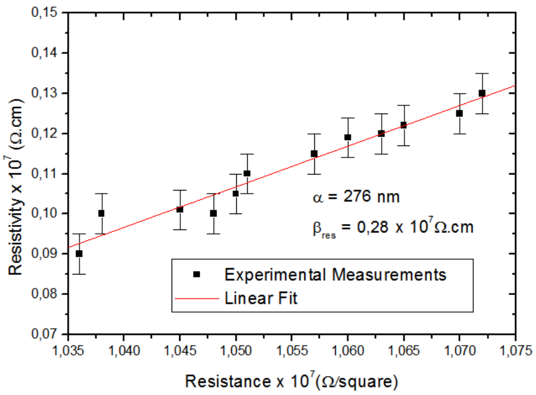

Figure 4. Electrical resistivity of the $LiClO_4$/PC/ PMMA/ITO/PVDC in function of sheet resistance.

The microscopic analysis performed in flexible organic battery by Scanning Electron Microscopy, has allowed us to observe the induction on the surface of the samples before and after the use of device with one OLED [12][13]. The charge and discharge voltage was 3 Volts. This voltage is sufficient for OLED activation. Figure 5 has shown the micrograph of flexible organic battery before voltage charge the 3 Volts. It may be observed that the surface of the sample has some homogeneous aspect, plane and without changes. Figure 6 has shown the micrograph of organic battery after charge and discharge performed during six months on 24 hours/day. In this micrograph, it may be observed the surface of the sample in some irregular aspect, with holes and cracks. In addition, the formation of thick layers due to the migration of the organic semiconductor material can be observed. Therefore, these cracks can contribute to reducing the lifetime of the flexible organic battery, since the accumulation of organic semiconductor material may cause short circuit in the device.

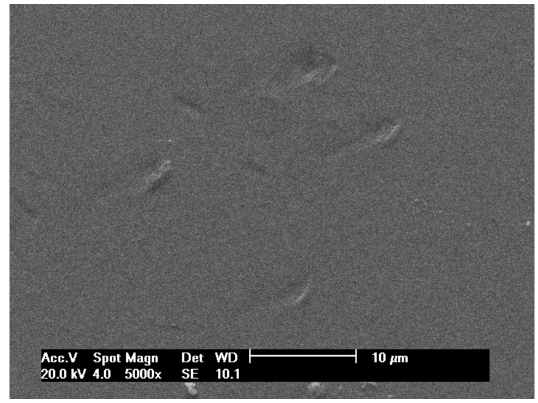

Figure 5. SEM of flexible organic battery before voltage charge.

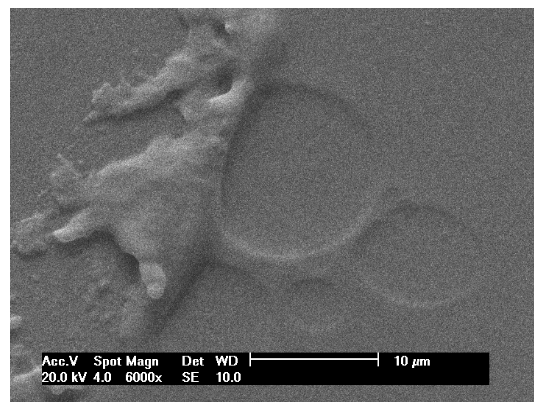

Figure 6. SEM of flexible organic battery after voltage charge.

4. CONCLUSIONS

The results presented in this research are that PANI-X1/ $LiClO_4$/PC/PMMA can be utilized as an active layer of flexible organic battery. These organic semiconductor materials can be deposited spin-coating and Electrodeposition. The absorption spectrum in the spectral region of 200-1100 nm of the organic battery, has indicated that there is no increase in absorbance with the utilization of these deposition techniques. The results of electrical measurements have demonstrated that, when the layer of organic material is completely conductive, we can obtain the thickness of the organic material deposited on the substrate. Therefore, the flexible organic battery developed with the proposed architecture has presented the best optical and electric result, demonstrating the feasibility for manufacturing flexible organic battery, which have electrodes with PVDC/ITO/PANI-X1 and $LiClO_4$/PC/PMMA/ITO/ PVDC.

5. ACKNOWLEDGMENTS

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