Fabrication of Pb doped Polyaniline thin film based Supercapacitor

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***Abstract* - Today's need of society is generation and storage of energy. The energy can be stored by different means but recent focus is on energy storage devices such as supercapacitors and batteries. Among the polymers, polyaniline shows conductivity for the specific oxidation and reduction state. The Pb doped polyaniline thin films were synthesized using simple and cost effective Successive Ionic Layer Adsorption and Reaction (SILAR) method and are used as to fabricate supercapacitor device. Variation in the deposited mass with respect to deposition cycles was studied also the charging and discharging studies were carried out.**

***Index Terms*—Supercapacitor, Energy Storage, Polyaniline thin films.Conducting Polymer.**

I. INTRODUCTION

In response to the global changes, energy has become a main focus of the major world power and scientific community. In today's era, energy generation and storage became a very important and interesting topic. There is a need of highly efficient energy storage devices. At present, batteries are used to store energy in electronic equipment's based on electrochemical reactions within them to store the charge. On the other hand capacitors stores electricity directly, charged instantly and also delivers the energy at very fast rate due electrostatic mechanism of charge storage. They can also provide more power than batteries, much more durable than other batteries with less degradation.

Supercapacitors which are also known as electrochemical capacitors or ultracapacitors make use of high surface area electrode materials to achieve capacitances several orders of magnitude larger than conventional capacitors [1-3]. Supercapacitor can be used in electrical vehicles where high power density is needed to accelerate vehicle and the energy can be recovered during braking [4].

Conventional capacitor consists of two plates separated by dielectric material. When potential is applied across the plates, opposite charges accumulate on the surfaces of each plate. The charges are kept separate by dielectric or insulating material which produces electric field that allows the capacitor to store energy. Capacitance C is defined as the ratio of stored (positive) charge Q to the applied voltage

$$c = \frac{Q}{V} \text{---} (1)$$

Also, for conventional capacitor, capacitance is directly proportional to surface area and inversely proportional to the distance between the plates.

1.1CLASSIFICATION OF SUPERCAPACITORS

The classification of the supercapacitors is based on the energy storage and charge distribution [5-6]. Depending upon this the supercapacitors are classified as

Double Layer Capacitors

In this type, the charge storage occurs at interfaces between the electrolyte and electrode. The value of capacitance depends upon electrode surface area that is available to electrolyte ions [7]. In these types of supercapacitors, there is no chemical reaction involved in this charge storage mechanism.

Pseudocapacitors

In this type, a fast reduction oxidation reaction occurs at the surface of the electrode [8]. This type of pseudocapacitors can provide greater values of capacitances and energy densities as compared to double layer capacitors. Among the different types of electrode materials used for pseudocapacitors conducting polymers such as polyaniline (PANI) or polypyrrole (PPy) have shown good capacitance values [9].

Hybrid capacitors
A supercapacitors which shows the features of both double layer supercapacitors and batteries and act as high power-high energy storage devices is called as hybrid capacitor. [10]

Currently, there is a need to focus on supercapacitors are improvement in the energy density while maintaining high power density, fast charge/discharge and cycling stability. Equally, the electrode material also plays important role in the supercapacitive properties. The polymer based supercapcitor with different types of doping are of great interest.

II. EXPERIMENTAL WORK

A. Substrate Cleaning

Stainless steel substrates are used to deposit the Pb doped polyaniline thin films using SILAR method. The top substrates were mirror polished using zero grade polish paper. This process creates nucleation sites over the substrate surface. The substrates were cleaned using distill water and acetone and used for the deposition. The cleaning was done two to three times in order to avoid the contamination of other particles.

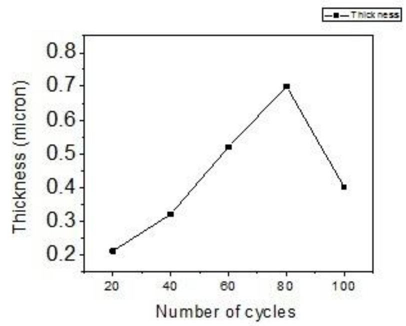
B. Optimization of Concentration

Four beaker system was used to deposit the thin film. First and third beakers contained the cationic and anionic precursors respectively and second and fourth beaker contained water for removing loosely bound ions. Following table illustrates the optimized concentrations of the precursors used

Solution Bath –I	Concentrations
Aniline + $PbCl_2$ + H_2SO_4	0.1 M, 0.05 M, 0.1 M
Solution Bath –II	Concentration
Ammonium per Sulphate	0.1 M

C. Optimization of Thickness

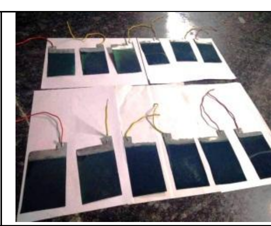
Variation of Pb doped polyaniline film thickness with number of cycles is as shown in Fig. 1. Thin films were deposited using SILAR Method. It was found that thickness of Pb doped polyaniline thin film increases with increase in number of cycles. Further increase in deposition cycle produces thick films. It was observed that the film thickness decreases with further increase in number of deposition cycles. The films with 80 cycles are found to be more stable and well adherent to the substrates. For the fabrication of supercapacitor the films with 80 deposition cycles were used.



III. FABRICATION OF UPERCAPACITOR MODEL

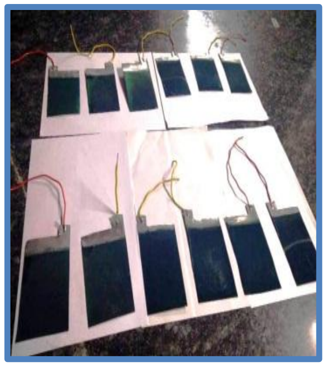
Steps involved in the fabrication of Pb doped polyaniline based Supercapacitor are as follows

3.1 Step-I
The stainless steel substrates were used for the deposition of the Pb doped polyaniline thin films. The films are prepared as stated in the point 3.1. The films were deposited using SILAR method using 0.1 M Aniline as a one bath and other contains the 0.1 M solution of ammonium per sulphate. The 3 x 2 inch substrates were used for the deposition. The thick bottle green colored

	
Stainless Steel Substrate before Deposition	After Deposition of Pb Doped Polyaniline Thin Film

films were obtained on stainless steel substrates.

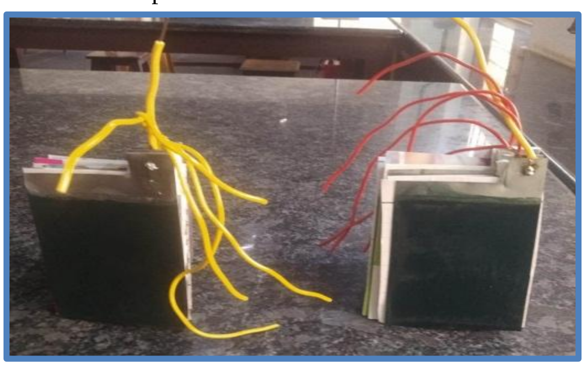
3.2 Step-II
The deposited large area films are bunched together to form electrodes. For each stainless steel substrate, a separate wire was soldered to have the parallel connection between the substrates/plates. The separate electrodes are as shown in figure below



Pb doped polyanline thin fillms with contacts

3.3 Step-III

The capacitance decides the energy storage capacity of the capacitor. Energy storage increases if the plated are in parallel combination. These bunched parallel plates are used as one electrode as shown in Photograph. In this photograph two separate electrodes are present.



Pb Doped Polyaniline electrodes

3.4 Step-IV

The separate electrodes are placed in the plastic container. From the top of the container contacts are drawn. The separate connectors are used to connect the supercapacitor to the power supply. The constant current source is used to charge the capacitor.

Pb Doped Supercapacitor

IV CHARGING AND DISCHARGING STUDY

The charging discharging study was carried out using constant current source and Light Emitting Diode (LED).The constant current from 40 mA to 80 mA was applied across the electrodes and discharging time and intensity of the LED was noted. The increase in charging current slightly increased the discharging time but the intensity of LED increased.

VII. CONCLUSION

The large area Pb doped polyaniline thin film deposition was carried out on stainless steel substrate by chemical method. The supercapacitor fabricated using these films showed good response to charging and discharging and a potential candidate for supercapacitor.

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