CHAPTER I

INTRODUCTION

Conducting Polymer

A key discovery in the development of conducting polymers was the finding in 1973 that the inorganic polymer, polysulfurnitride $(SN)_x$ is a metal. This was the first polymeric material that was shown to have metallic properties. These discoveries were of particular importance because they proved the existence of highly conducting polymers and stimulated the enormous amount of work necessary to synthesize other polymeric conductors.

The major breakthrough in the area of conducting polymer occurred later in 1977 when the same redox chemistry was applied to an intrinsically insulating organic polymer, polyacetylene. It was discovered that polyacetylene, which was insulator could be made highly conducting, $\sim 10^5$ Scm^{-1}, by exposing it to oxidizing or reducing agents. This process is often referred to as "doping". The insulating neutral polymer is converted into an ionic complex consisting of polymeric cation (or anion) and a counterion which is the reduced form of the oxidizing agent (or oxidized form of the reducing agent). In solid-state physics terminology, the use of an oxidizing agent corresponds to p-type doping and that of a reducing agent to n-type doping. It is doping reactivity of the π-electron conjugated system which induces such unique electronic conductivity in polyacetylene. Since the conjugated backbone holds the key to higher conductivity, therefore, based on similar fundamentals, a large number of organic conducting polymers have been generated in the 1980[1].

Organic polymers which have been looked upon for decades as insulators in the electronic industries have emerged as a new class of electronic material. Some of the important polymers of the conducting family are polyacetylene, polyaniline, polypyrrole, poly(p-phenylene), poly(p- phenylene sulfide), poly(p-phenylene vinylene) and polythiophene. The electrical conductivity of these conjugated organic polymers can be varied over a wide range by chemical or electrochemical doping, thus making it possible to consider them for a variety of electronic applications.

Conducting polymers are not only comparable to inorganics from the point of view of metallic conduction, but, in addition, they also impart a blend of interesting optical and mechanical properties. One of the greater advantages of organic polymers over inorganic materials is their architectural flexibility, since they can be chemically modified and easily shaped according to the requirements of a particular device. Their versatility and compatibility coupled with durability, environmental stability, ease of fabrication and light weight make them most fascinating materials for electronic devices[2].

Of many polymers, polypyrrole has become one of the most attractive conducting polymers due to the properties of high electrical conductivity and thermal and environmental stability[3]. In preparing conducting polypyrrole, there are three methods generally used to prepare polypyrrole (i) chemical polymerization in solution (ii) chemical vapor deposition and (iii) electrochemical polymerization. Most investigators have been interested in the third method. In fact, more than 300 reports concerning electrochemical polymerization of polypyrrole and their electrical, morphological and mechanical properties have been published. On the other hand, the chemical polymerization method, which can be traced back to 1916, is less popular due to less conductivity

However recently, Machida et al. found that polypyrrole obtained from chemical polymerization in solution, can exhibit very high electrical conductivity when suitable solvent was selected and the oxidation potential in the solution was controlled. Furthermore, this method has a greater advantage over other methods since large quantity of polypyrrole can be conveniently prepared [4].

Within the last few years, various electronic devices based on conducting polymers have been produced [2]. These electroactive materials cover a broad spectrum of applications from solid-state technology to biotechnology. The first major area of application includes solid-state rechargeable polymer batteries. Because of the versatility of polymeric systems, they can be easily shaped according to the requirement of a device. Furthermore, the electrochemically studies have shown that their rechargeability should be comparable to that of inorganic batteries. These two factors make them competitive to inorganic electrode-active materials.

In the development of polymer batteries, BASF and VARTA Batterie A.G. of West Germany have used polypyrrole synthesized from electrochemical polymerization as positive electrode in rechargeable battery since polypyrrole synthesized by this method showed good electrode properties. It can switch between conducting and insulating forms by electrochemically doped and undoped processes without loss of activities. When electrochemically synthesized polypyrrole is used with lithium negative electrode and electrolyte solution of lithium perchlorate in propylene carbonate, rechargeable battery of high cell voltage (3.5V) is obtained [2].

In this research, we are interested in the possibility of using chemically synthesized polypyrrole, which prepared by a different method, as an electrode of rechargeable battery. The first investigation is to study electrode properties of this chemically synthesized polypyrrole, specifically the electrochemically abilities, by cyclic voltammetry. If chemically synthesized polypyrrole shows good electrode properties, the rechargeable batteries with this polypyrrole as a positive electrode will be constructed and investigated.

Objectives and Scope of the Research

Objectives

The main objective of this study is to investigate the possibility of using chemically synthesized polypyrrole as a positive electrode of rechargeable battery and the comparison of its performance with that of electrochemically synthesized polypyrrole electrode.

Scope of the Research

1. To synthesize polypyrrole by an electrochemical method in the solution of tetrabutylammonium perchlorate in propylene carbonate.

2. To synthesize polypyrrole by a chemical method in the solution of ferric chloride in methanol.

3. To study electrochemical properties of both polypyrrole synthesized by electrochemical and chemical methods using cyclic voltammetry.

4. To apply polypyrrole synthesized by both electrochemical and chemical methods as an electrode for the rechargeable batteries and to investigate the performance of these batteries.

It is expected that the results from this research will be able indicate the application of conducting polymer in rechargeable battery.