CHAPTER I

INTRODUCTION

1.1 Electroactive polymer

Electroactive polymers have been the new object of increasing academic and industrial interest. Since 1970 the substantial progress has been achieved in the development and characterization of this important new class of conducting materials. These conductive materials are usually classified in two large groups, according to the mode of their electric transport. One group includes polymer having transport almost exclusively of the ionic type and they are often called 'polymer electrolytes'. The other group which are termed 'conducting polymers' includes polymeric materials where the transport mechanism is mainly electronic in nature. It may be divided into three forms due to different applications. First, it is used as active elements in electronic devices. Second, carbon- or metal- filled polymers are increasingly utilized as moldable semiconductors. Third, charge transport property in electronic conductors, includes conjugated polymers with the dopant, e.g., $FeCl_3$ involving oxidation (removal of π electrons) process or Na, which offer the reduction process (addition of π electrons) can render the electrical conductivity on the polymer chain [1].

The electrical transport properties in conducting polymers offer the good advantage which can not be found in general materials such as metal, or carbon for the same object. Light weight, low cost, moldability, and sometimes mechanical flexibility that are the nature of these conductive materials can guide to wide range

applications. The examples for practical applications are rechargeable batteries, electrolytic capacitors, sunlight absorber, microwave absorber, corrosion protection, and magnetic shielding [2].

One of the conducting polymers, polyacetylene, which was first synthesized by Shirakawa et al. [3], has many conjugated double bonds which can serve as conducting transport by adding oxidizing agent or reducing agent. Most of the doping processes for polyacetylene that transforms from an insulator to a good conductor is ordinarily oxidation process by using ferric chloride. The other polymers which have the analogous system to polyacetylene, but have heteroatom in their molecules are heterocyclic polymers, such as polypyrrole, polythiophene and their derivatives, and polyaniline. Polypyrrole was firstly synthesized in 1968 [4]. The polymerization of pyrrole and thiophene was succeeded through α,α'-coupling (2,5-position) and both polymers are structurally similar. The molecular structures of polypyrrole are shown in Figure1.1.

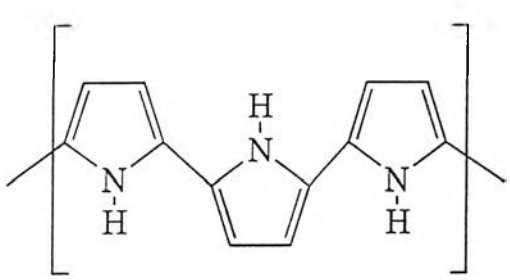

Figure 1.1 The structure of polypyrrole molecular chain

At present, various reports are revealed to show high electrical conductivity of conducting polymers that have conjugated bond system with heterocyclic molecule, especially, polypyrrole. The synthesis of polypyrrole was studied to obtain high electrical conductivity both in electropolymerization and chemical polymerization

method. Although polypyrrole is stable and has good conductivity, it is hard and brittle material too [5]. Moreover, various factors such as reaction temperature, reaction time, and nature of dopant may degrade polymer quality. These factors affect the electron transport in polypyrrole chain which lead to low conductivity.

Moreover, other conductive polymers have been studied. Some polymers were easily prepared by electropolymerization while the others were prepared by chemical polymerization. All of the conducting polymer, however, required the method which could make the processability, stability, and acceptable expense to those of conducting polymer.

1.2 Conducting polymer composites

In order to expand applications of conducting polymer such as polypyrrole and polythiophene, properties of this class of materials were investigated. Various attempts to synthesize conducting polymer composite have been made widely in the modern applied chemistry research. Initially, the simplest conducting composites consist of a fine metal or carbon powders dispersed uniformly throughout an insulating plastic matrix were investigated [6]. This method can make conducting polymer although the less metal or carbon particles used in high concentrations tend to destroy desirable mechanical properties. Moreover, the metals have the high expense too. Silver, Platinum, or gold, which has high electrical conductivity (10^4-10^6 Scm^{-1}), is very expensive. For a good quality carbon, it was well known that the price is high too.

Modern conducting composites using polymers only two or more types occurs in this time. Most of the methods have one insulating polymer act as core or smooth plate. The other polymer is the conductive polymer such as polypyrrole, polyaniline, etc., which covers the core or insulating plate. Then, they form the composite. Polymer are considered as highly promising new materials for electronic devices, electrical applications, electrochromic displays, polymer batteries, and polymer modified electrodes, so the different properties of these composite are necessary. In fact, the use of its only one characteristic for various applications is impossible. The changing of polymer composition can improve the disadvantage of each composite. One type of conducting polymer blends with another insulating polymer can use in a wide range of application if the compositions designed are appropriated.

Generally, blends of polypyrrole and insulating polymers can be chemically prepared by different methods. The most reported routes include [7]:

(1) Dissolution of the insulating polymer in a solution of an oxidizing agent. Stabilized polypyrrole colloidal solutions are obtained by adding pyrrole under stirring [8]. Powder composites are prepared by evaporation of colloidal solutions.

(2) Covering of polymeric films or textiles by polypyrrole. The insulating matrix is immersed in a mixture of oxidizing agent and pyrrole [9].

(3) Interfacial polymerization. An insulating polymer separates a monomer solution and a solution of an oxidizing agent. The monomer and oxidant diffusing across the matrix and the polymerization occurs [10].

(4) Preparation of blends by swelling of insulating matrices in a solution of an oxidizing agent, followed by exposure to pyrrole vapors [11-14].

(5) Preparation of blends by mixing the insulating polymer and oxidizing agent solutions, followed by film casting by solvent evaporation. The matrices containing oxidant are subsequently exposed to monomer vapors [15].

Polypyrrole is the most of conducting polymer that is chosen for composite research because its conductivity, air and thermal stability are rather good. Commonly, the combining of polypyrrole with insulating polymer is well known. Different synthesis procedures have been reported. The use of insulating polymer such as polystyrene, poly(vinyl chloride), polypropylene, polyethylene, and poly (methylmethacrylate) [16] to prepare electrical composites was investigated thoroughly. High conductivity of polymer composites, however, has not been exhibited yet. Moreover, the processability is still difficult. Those polymer

composites are not good enough for commercial applications. For the above reason, the improvement of composite properties to ease the application for the practical work is very important. This research is a study of parameters effect conductivity, thermal stability, and processability of composite. By using the intrinsic condition for synthesize high conductivity [5] the conductivity of polypyrrole composite which is prepared by our route can be the. It increases the interesting of conducting composite more later.

1.3 Objective and scope of research

The purpose of this thesis is to synthesize a highly conducting polypyrrole composite by using the concept of our previous research. Various types of host polymers are used to produce the polypyrrole coating composite, and then study the effects of prepared conditions such as monomer volume, solvent, reaction time, and reaction temperature in order to find the suitable procedure which yield to polypyrrole composite of desired properties. Analogous to the chemical synthesis of polypyrrole composite, pure polypyrrole is synthesized in the dispersion polymerization without host polymer but there is a stabilizer in the reaction media instead. Finally, some instruments are used to characterize the properties of polymer samples to prove that the feature of the product is right as required.

The procedure in this research was planned and worked in the limited time. Each step was done completely as follows:

(1) Literature survey

(2) Designing the devices for investigation

(3) Synthesis of polystyrene powder by emulsion polymerization

(4) Synthesis of polypyrrole composite by chemical polymerization under the influence of

(4.1) host polymer type

(4.2) pyrrole volume

(4.3) reaction time

(4.4) solvent

(5) Synthesis of dispersion polypyrrole by chemical polymerization under the influence of

(5.1) pyrrole volume

(5.2) reaction time

(5.3) solvent

(6) Measurement of the electrical conductivity of prepared polypyrrole products by van der Pauw method.

(7) Characterization of the properties of composite by

(7.1) Fourier Transform Infrared Spectroscopy

(7.2) Scanning Electron Microscopy