

CHAPTER 1

INTRODUCTION

1.1 Background

A solar cell is a device that directly converts light into electrical energy through the photovoltaic process. Photons from the sun can interact with atoms in matter. If sufficient energy is available, electrons can be released. In order to make solar cells produce electricity, it must be able to “collect” the free electrons. The electron flow constitutes the photocurrent. One of the main components in DSSC is the electrolyte that contains the redox couple. The redox couple provides free ions in the charge generation step that occurred when the dye absorbs visible light to form an electron-hole pair. The dye will inject electrons to the conduction band of a semiconducting layer. The holes are filled back with electrons from a redox reaction. Redox couples such as Fe/Fe^+ , SCN/SCN^- , I/I^- have been used in solar cells.

Salts with iodide anion have been used in the application of DSSCs and these include lithium iodide (LiI) [1-3], ammonium iodide (NH_4I) [4], 1-methyl-3-propylimidazolium iodide (MPII) [5] and tetrapropyl ammonium iodide ($\text{Pr}_4\text{N}^+\text{I}^-$) [6]. Since we want to use I/I^- redox couple we fix the salt as LiI since the size of Li^+ cation is small and thus leads to better conductivity [7].

The efficiency of DSSC will depend on fill factor. However, fill factor depends on V_{OC} and I_{SC} . The two parameters depend on the conductivity of the polymer electrolytes. Conductivity of polymer electrolyte is of the order $\sim 10^{-4} \text{ S cm}^{-1}$. The type of polymer electrolyte is also important in DSSC fabrication and investigation. Numerous liquid

electrolytes have been applied in dye-sensitized solar cells (DSSC). Wongcharee et. al [8] have used liquid electrolytes consisting of iodide electrolyte solution, prepared by dissolving 0.05 mole iodine in one liter water-free ethylene glycol. A solution of 4-tert-butylpyridine (4-TBP) mixed with acetonitrile [9-10] has been used as liquid electrolytes. However, liquid electrolytes possess some disadvantages such as leakage, evaporation of the solvents, electrochemical corrosion, instability of liquid electrolyte at high temperatures, possible desorption and photodecomposition of the dye in the solvent medium and it is also difficult to fabricate the DSSC [1,11-14] using liquid electrolyte. Liquids also have no mechanical strength and thus introduce several constraints on cell design [15]. Thus, due to the problems encountered with the use of liquid electrolyte mentioned above, research has been geared towards the development of good polymer electrolyte in the solid/pseudo solid form.

Solid polymer electrolytes (SPE) offer many advantages such as fast ion transport, good mechanical strength, electrochemical stability and the ease of fabricating thin films [5-6]. One of the most popular SPE host is polyethylene oxide (PEO) since it is a good solvent for lithium salts, due to its excellent solvating properties [16-20]. However, PEO possesses some disadvantages such as being semicrystalline and fast aging. So we need to find a polymer that is more amorphous than PEO as high conducting polymer electrolytes are amorphous. An example of a polymer is chitosan as can be observed from works of Majid et. al [20]. Chitosan is one of the common polysaccharides that have great ability to form films with good mechanical properties leading to occasional applications as solid polymer electrolytes [21].

However, chitosan has its problems such as limited available solvents to dissolve it. Many solvents that can dissolve chitosan contain water. Water is detrimental to Li ion conductors because Li^+ salt is already hygroscopic. Thus, it is better to choose non-aqueous solvents. Therefore, if chitosan is to be the choice, then it has to be modified.

In this work, since we want to study DSSC with I/I⁻ redox couple, we therefore used lithium iodide as the salt to provide the I⁻ ion and the polymer host to be chosen is chitosan. The objective of the present investigation is as listed in the following section.

1.2 Objectives of the Present Investigation

1. Since we need to improve the solubility of chitosan in polar aprotic solvents, modifications need to be done. By applying phthaloylation, inter/intra hydrogen bonding within and between chitosan monomers will be disrupted thus lead to better solubility.
2. LiI is introduced in the polymer host. The higher the conductivity, the better will be the I_{SC} . Therefore, PhCh-LiI must be optimized for better conductivity.
3. In order to test for complexation, the polymer electrolytes will be characterized using FT-IR and x-ray diffraction.
4. Finally, the highest conductivity PhCh-LiI will be applied in the fabrication of DSSC using anthocyanin dye extracted from black rice and red cabbage in the effort to demonstrate the functionality of the chitosan-anthocyanin combination in a workable DSSC.

1.3 Scope of Research Work

An overview of the development and characteristics of the polymer electrolytes are presented in Chapter 2. Chapter 3 will discuss the experimental procedures of the modification of chitosan and preparation of the polymer electrolytes. Characterization of the modified chitosan and the polymer electrolytes are also explained in this chapter. This chapter ends with fabrication of the dye-sensitized solar cell using the natural dye as the sensitizer.

Chapter 4 covers the results and discussion obtained from this study. This chapter consists of three main parts. The first part is the verification of the structure of the modified chitosan and its physical properties including its crystallinity and solubility. The second part deals with the phthaloylchitosan as the polymer electrolyte host. The influence of salts on the conductivity behavior and their interaction will be discussed in this chapter. In addition, temperature dependence of the conductivity will be also presented in this chapter including the electrical studies. The results of application of the polymer electrolyte from this modified chitosan in DSSC are presented as the last part of this chapter. The whole study will be concluded in Chapter 5. This chapter also reveals the suggestions for further works. The summary of current works is illustrated in *Figure 1.1*.

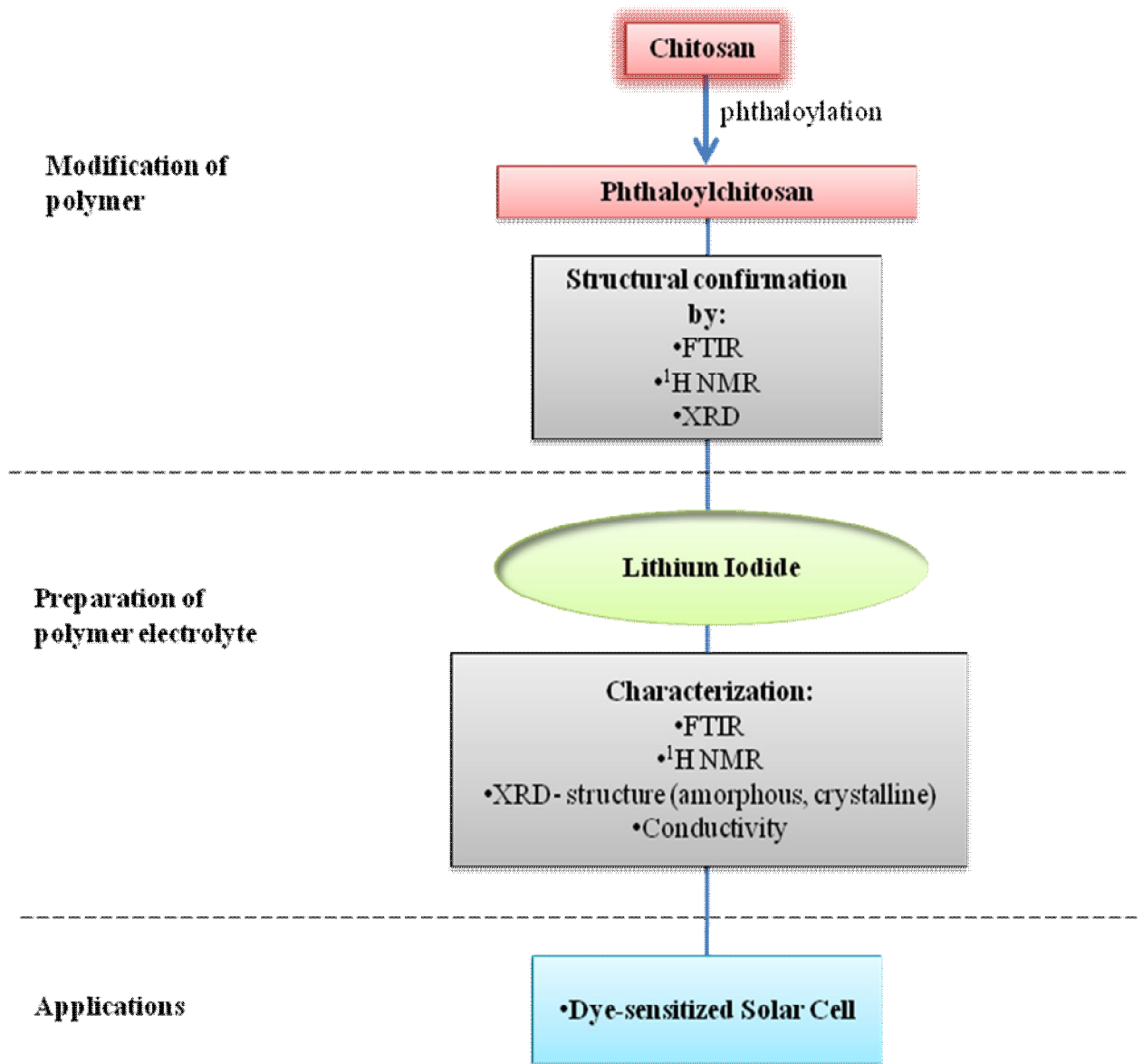


Figure 1.1: Flow chart of work