CHAPTER 1

1.0 Introduction

The sun is the ultimate resource of energy for every single life form on earth. The energy from the sun had been successfully harvested by plants and photosynthetic micro-organisms and converted it to chemical energy in the form of food and eventually used the energy from the food for their survival. In the process of evolution they have been optimized and perfected over and over for more than 3.8 billion years in order to produce the most efficient and optimized system that is existing today. Thus, it is no surprise that the recent scientific community have diverted their attention to study how plants and the photosynthetic micro-organisms efficiently harness the solar energy so as to emulate its models and process to incorporate them in to practical applications.

One such study that has attracted great interest of the scientific community is on a photosynthetic membrane protein called Bacteriorhodopsin (bR). bR is a retinal protein that can be found in the purple membranes of *Halobacterium salinarum*. It is an efficient and simplest known biological energy conversion device which upon absorbing a quantum of photon, goes through a photo-isomerization process and subsequently translocates a proton from the cytoplasmic to the extracellular side of the membrane. The electro-chemical gradient that produced by the different concentration of proton across the membrane, is then utilized to synthesize Adenosine Tri Phosphate ATP. This simplest form of proton pumping mechanism have found to posses many possible practical application in the field of photoelectric [1], photosensing[2], photochromic [3], nonvolatile memory[4-5] energy converting system [6] and many more. These made bR to be one of the most successful biomaterial that used in many electronics, memory and photonic devices. All the above mentioned advantages of bR have also attracted my interest to study more about this material and contribute some of our findings to the scientific world.

1.1 Objective

As mentioned earlier, bR have been extensively researched and successfully utilized in many scientific and technological devices. Almost in all its fabrication, bR have been exclusively configured in highly oriented, functionally active monolayer to multilayer thin film. For this, many methods such as Langmuir–Blodgett [7], electrostatic sedimentation [8], chemisorption [9], antigen–antibody interactions [10], and electrostatic layer-by-layer assembly [11-12] techniques have been successfully utilized. Among these methods, Langmuir Blodgett (LB) seems to be more favoured by many researchers as it allows precise deposition of compactly packed monolayer to multilayer thin film. In LB technique, there are many parameters such as, sub-phase[13] type of solvent used to mix bR suspension [14] and many more that influence the quality of the thin film that is deposited. The mechanical and electrical properties (surface potential) of the bR thin film based on the surface pressure – area isotherm also have been analysed to suggest optimal conditions for thin film deposition [17].

However, one important parameter that was not studied in the previous works is the thermodynamically most optimum condition for thin film deposition. As such the main aim of this thesis is to analyze the mechanical and thermodynamic properties of Bacteriorhodopsin - Langmuir monolayer film from the surface pressure area-per molecule isotherm. Then based on the analysis, a mechanically and thermodynamically optimal surface pressure for the bR thin film deposition is suggested. In this respect the presented work here is novel.

1.2 Thesis Structure

This thesis is divided into 5 chapters. In the first chapter we start with introduction to this thesis and then we briefly look into the objectives of the thesis. The second chapter is dedicated on literature review on bR and LB technique. A brief history of bR, its structure, function and applications in modern technology is discussed in section 2.1. Similarly a brief history of LB technique, its importance and advantages over other self assembly methods are discussed in section 2.2. Previous works done on the bR-LB films and the scope of the thesis is discussed in section 2.3. In the sub-sections of 2.3 we also discussed some theories related to the thermodynamic properties and structural characterization of bR thin film. Chapter 3 will discuss the experimental procedures in detail, including how to produce the bR solution and spreading emulsion without sonication, and preparation of the LB trough for film deposition.

The results and discussions are presented in Chapter 4, where the surface pressure – area isotherm is analyzed at different concentration. Also the compressibility modulus versus area per molecule is analyzed to show different phases of the bR monolayer. Thermodynamic properties such as Gibbs free energy, Enthalpy and Entropy of compression are also calculated and discussed. Various spectroscopic characterizations done on the deposited films were also presented here. Finally in chapter 5, the results and analysis in chapter 5 are concluded and suggestions for future works are presented.