APPLICATION OF CHITOSAN BIOPOLYMER AS A SENSING MATERIAL

BY

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A THESIS SUBMITTED IN FULFILLMENT OF THE REQUIREMENT FOR THE MASTER OF SCIENCE POLYMER ENGINEERING

SCHOOL OF MATERIAL ENGINEERING

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APLIKASI CITOSAN BIOPOLIMER SEBAGAI BAHAN SENSOR

DARIPADA

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TESIS YANG DIKEMUKAKAN UNTUK MEMENUHI KEPERLUAN BAGI MEMPEROLEHI IJAZAH SARJANA SAINS KEJURUTERAAN POLIMER

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APPROVAL AND DECLARATION SHEET

This project report titled Application Of Chitosan Biopolymer As A Sensing Material was prepared and submitted by ROSHIDA BINTI MUSTAFFA (Matrix no:0831620290) and has been found satisfactory in terms of scope, quality and presentation as partial fulfillment of the requirement for the Master of Science (Polymer Engineering) in University Malaysia Perlis (UniMAP).

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2009

ABSTRAK

Aplikasi Citosan Biopolimer Sebagai Bahan Sensor.

Larutan citosan telah berjaya diletakkan diatas wafer silikon menggunakan "sol gel" kaedah untuk memfabrikasikan citosan pengesan filem nipis. Kesan suhu penyepuhlindapan yang berbeza itu dan masa penyepuhlindapan untuk ciri-ciri elektrik telah diukur tanpa dan di bawah pencahayaan lampu. Pengesan filem nipis citosan menunjukkan ciri-ciri kepekaan Voltan (I-V) bergantung kepada suhu penyepuhlindapan dan masa penyepuhlindapan. Kesan penyepuhlindapan suhu, mendapati filem yang disepuh $190^{o}C$ *adalah yang tertinggi "photocurrent" berbanding dengan lainnya. Manakala kesan masa penyepuhlindapan menunjukkan lebih tinggi masa penyepuhlindapan, lebih tinggi "photocurrent". Perubahan dalam "photocurrent" itu menyatakan hubungan mikrostruktur dengan citosan pengesan filem nipis adalah berbeza. Walaupun nilai photocurrent kepada filem itu berubah-ubah, iaitu dengan adanya pencahayaan dan tanpa pencahayaan lampu. Keseluruhan nilai "photocurrent" citosan filem nipis adalah peka kepada cahaya biasa dan cahaya "UV". Oleh itu, ia mempunyai potensi yang baik sebagai alat pengesan cahaya filem nipis.*

ABSTRACT

Application of Chitosan Biopolymer as a Sensing Material.

The chitosan solution has been succesfully deposited on the silicon wafer using sol-gel method to fabricate the chitosan thin film sensors. The effect of different annealing temperature and annealing time to their electrical characteristics were studied without and under light illumination. The current-voltage (I-V) characteristics showed that sensitivity of chitosan thin film sensors depend on the annealing temperature and annealing time. For the annealing temperature effect, it was found that the film annealed at 190^{o}C has the highest photocurrent compared to the others. While for the annealing time effect, it was shown that the higher annealing time, the higher photocurrent. The changes of photocurrent are related to the different microstructure of chitosan thin film sensors. Although, the photocurrent values of the films illuminated with light exhibit the fluctuation to the photocurrent values without light illumination. Overall the chitosan thin films are sensitive to the visible and UV light. Therefore, they have a good potential as thin film light sensors.

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LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURES

BOE	Buffered Oxide Etchant
PVD	Physical Vapor Deposition
SPA	Semiconductor Parametric Analyzer
SEM	Scanning Electron Microscope
AFM	Atomic Force Microscope
RMS	Root Mean Square
RA	Roughness Area
MS	Mean Size
MD	Mean Diameter
GA	Grain Area

UNIVERSITY MALAYSIA PERLIS

DECLARATION OF THESIS

Author's full name : **ROSHIDA BINTI MUSTAFFA.**

Date of birth : **30 OCTOBER 1979**

Title : **APPLICATION OF CHITOSAN BIOPOLYMER AS A SENSING MATERIAL.**

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CHAPTER 1

INTRODUCTION

1.1 Background

Sensors are widely used in numerous industrial applications and in our day to day activities. A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. As electronics seamlessly weave their way into our lives, sensors play an increasingly important role. Sensors provide us the important information that helps us to detect changes of vibration, light and amplified into signals for various industrial disciplines. Sensors and sensor systems make electronic control of today's technical system easier. It can support industrial processes and application to be more cost effective, reliable, and safe.

The invention of a new sensing material that is not harmful to environment is very important to develop the environmentally friendly sensors. Chitosan which is a bio-polymer has a potential to be investigated as photo sensing materials. Besides, it is safe and non toxic to environment and low cost for sensor fabrication. It is produced from reproducible resources by treating seafood waste, such as shells of shrimps, crabs, lobsters, krill, etc.

Chitosan are currently receiving a great deal of interest as regards medical and pharmaceutical applications because they have interesting properties that make them suitable for use in the biomedical field, such as biocompatibility, biodegradability and non toxicity. Moreover, other properties such as analgesic, antitumor, hemostatic, hypocholesterolemic, antimicrobian, and antioxidant properties have also been reported by (Kumar, 2000 & 2004; and Koide, 1998). So, chitosan is suitable for exploring the optimum conductivity of their functionality especially for new sensing material.

1.2 Objectives

- To fabricate thin film sensor based on chitosan biopolymer.
- To investigate annealing temperature, annealing time, their effect on the performance of the sensor and microstructure of chitosan thin film.
- To investigate the sensitivity of chitosan thin film on UV light, visible light and without light.

1.3 Scope of Research

The work is divided into three sections. Fabrication of chitosan thin film sensor is the first part of this work. The second section was devoted on microstructure of chitosan thin film and the effect of annealing temperature and annealing time to the performance of the sensor investigated. Testing of the chitosan thin film light sensor on several of light and without light has been done as the last part of this study.

CHAPTER 2

LITERATURE REVIEW

2.1 What is a sensor?

Sensor is a device, such as a photoelectric cell, that receives and responds to a signal or stimulus. The term "stimulus" means a property or a quantity that needs to be converted into electrical form. Hence, sensor can be defined as a device which receives a signal and converts it into electrical form which can be further used for electronic devices. A sensor differs from a transducer in the way that a transducer converts one form of energy into other form whereas a sensor converts the received signal into electrical form only. (Kretschmar & Welsby, 2005),

A sensor's sensitivity indicates how much the sensor's output changes when the measured quantity changes. Sensors that measure very small changes must have very high sensitivities. Sensors also have an impact on what they measure; for instance, a room temperature thermometer inserted into a hot cup of liquid cools the liquid while the liquid heats the thermometer. Sensors need to be designed to have a small effect on what is measured; making the sensor smaller often improves this and may introduce other advantages.(Kretschmar & Welsby, 2005)

Sensors are used in everyday objects such as touch-sensitive elevator buttons and lamps which dim or brighten by touching the base. There are also innumerable applications for sensors of which most people are never aware. Applications include cars, machines, aerospace, medicine, manufacturing and robotics. (Grimes et al., 2006)

A good sensor obeys the following rules:

- Is sensitive to the measured property
- Is insensitive to any other property
- Does not influence the measured property

Ideal sensors are designed to be linear. The output signal of such a sensor is linearly proportional to the value of the measured property. The sensitivity is then defined as the ratio between output signal and measured property. For example, if a sensor measures temperature and has a voltage output, the sensitivity is a constant with the unit [V/K]; this sensor is linear because the ratio is constant at all points of measurement.

2.2 Chitosan

The Chitosan (CS) is known to be non-toxic and odourless. So much interest has been paid to its industrial applications in the past decade (T. Ikejima et al. 1999 & , Y. Shignemasa and S. Minami,(1995). In addition, chitosan is expected to be useful in the development of composite materials such as blends or alloys with other polymers, since chitosan has many functional groups, (R. A. A. Muzzarelli (1997) & Z. Zang, et al., (2000), such as hydroxyls, amines and amides.

Chitin and chitosan are polysaccharides that support numerous living organisms. Chitosan is a nontoxic, biodegradable, and functional biopolymer consisting primarily of β linked 2-amino-2-deoxy-β-dglucopyranose units as shown in the Figure 2.1:

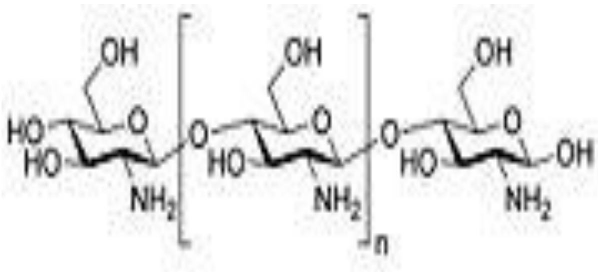

Figure 2.1: Chemical formula for chitosan

This polymer exhibits a unique combination of properties such as antimicrobial activity, chemical stability, biocompatibility, and good film forming properties. Chitosan is not a cellulose-like polysaccharide considering the presence of four elements in its formula, its cationicity, and the consequent capacity to form poyelectrolyte complexes and nitrogen derivatives, according to the chemistry of the primary amino group.

According to previous researcher Ravi Kumar et al., (2004) the film-forming ability of chitosan is another important aspect that cannot be found with cellulose. The film forming properties make chitosan attractive as anticorrosive multi-functional coatings for different applications. It is refer to Lundvall et al., (2007) & Pang et al., (2007). According to El-Sawy et al., (2001) & Sugama et al., (2000) the chemical structure of the chitosan can be easily modified resulting in different functional derivatives with desired properties needed for effective corrosion protection. The controllable release of the active compounds introduced to the chitosan films are also possible said Lundvall et al., (2007) making these films attractive for application when active corrosion protection is required.

Chitosan is a linear β (1→4)-linked 2-acetamido-2-deoxy-β-D-glucose (Nacetylglucosamine) that is obtained by the partial deacetylation of chitin. Because chitin deacetylation is incomplete, chitosan is formally a copolymer composed of glucosamine and N- acetylglucosamine.

Chitosan is soluble in acidic conditions due to the free proton able amino groups present in the D-glucosamine units. Due to their natural origin, both chitin and chitosan cannot be defined as a unique chemical structure but as a family of polymers which present a high variability in their chemical and physical properties.

This variability is related not only to the origin of the samples but also to their method of preparation. Chitin and chitosan are used in fields as different as food, biomedicine and agriculture, among others. The success of chitin and chitosan in each of these specific applications is directly related to deep research into their physicochemical properties.

It is important to note the term "chitosan" does not refer to a single well-defined structure, and chitosan can differ in molecular weight, degree of acetylation, and sequence whether the acetylated residues are distributed along the backbone in a random or blocky manner.

The properties of chitosan can also vary somewhat. In the following:

- The behavior of typical chitosan with a degree of accelation of 20% or less and a molecular weight on the order of 200kDa.
- The unique structural feature of chitosan and has many useful technologies applications such as technical grade for agriculture and water treatment.
- Pure grade for the food and cosmetics industries and ultra-pure grade for biopharmaceutical and agriculture (Chang et al., 2006 & Apiradee et al., 2007)
- High dielectric constant lowers dielectric loss, lower leakage current and almost negligible fatigue (Kemal & Fahrettin, 2008).

- The electrical properties of Chitosan thin film are affected by the deposition method and the effect of pH to Chitosan properties. These factors might cause the electrical properties of Chitosan thin film to better or worse (Pushpa & Srinivasan, 2008).

For the use of thin film sensor, Chitosan shows high responsibility, high sensitivity, repeatability, low energy consumption and good thermal stability. All these factors are required to produce Chitosan thin film as a potential -sensing device (Nurul, 2009).

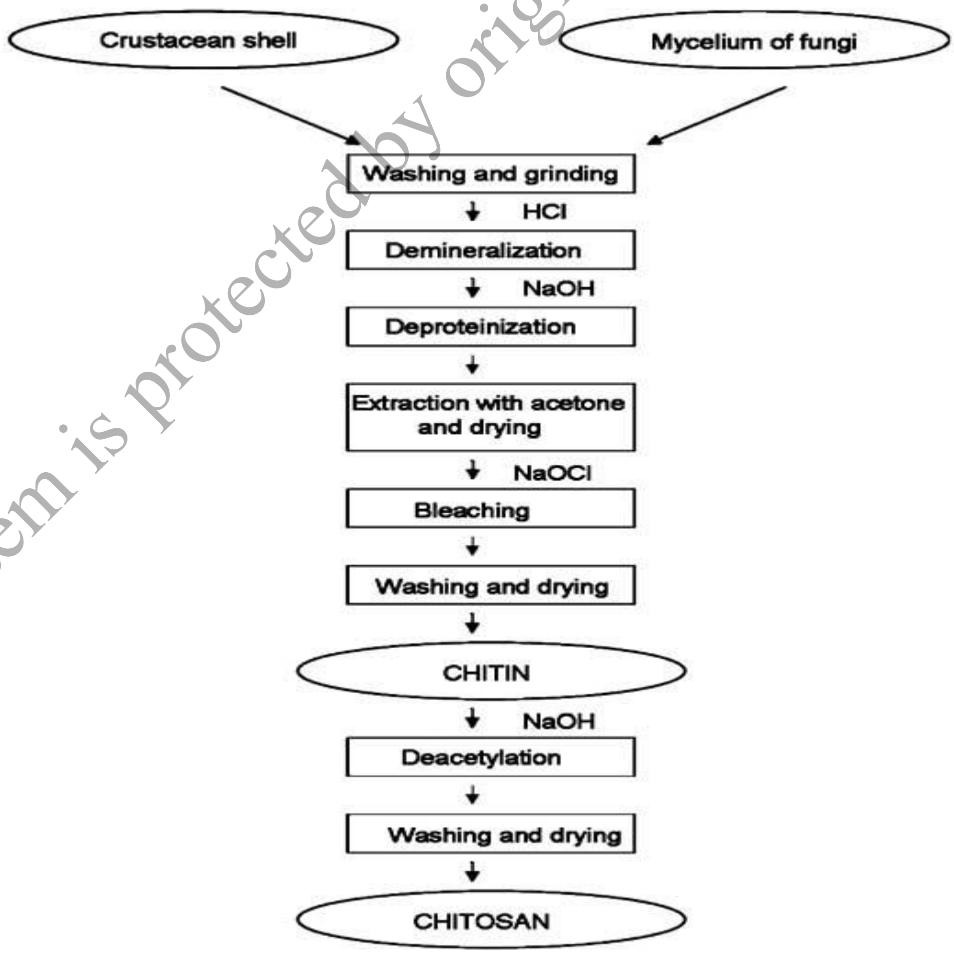

Figure 2.2: Preparation of chitin and chitosan from raw material.

(Source: Inmaculada A, et al., 2009)

Both chitin and chitosan possess many properties that are advantageous for wound healing like biocompatibility, biodegradability, hemostatic activity, healing acceleration, non-toxicity, adsorption properties and anti infection properties.

However, pure chitosan films have poor tensile strength and elasticity. Hence development of high strength composites are biocompatible can help in wound healing may be necessary for wound dressing applications. An attempt has been made to develop a composite film from chitosan by incorporating chitin nanofibres to improve its tensile strength and elasticity. Nanocomposite films were prepared from chitosan by solution casting after incorporating chitin nanofibres as nanofillers. Present study suggests that the tensile strength of the chitosan films can be increased up to a significant level by incorporating chitin nanofibres without appreciable change in water vapor permeability.

An effective wound dressing not only protects the wound from its surroundings but also promotes the wound healing by providing an optimum microenvironment for healing, removing any excess wound exudates and allowing continuous tissue reconstruction. Mechanical property is one of the critical and important characteristic of a wound dressing. Chitosan has been studied as an excellent wound dressing film.

However, pure chitosan films have poor tensile strength and elasticity. Hence development of high strength composites that are biocompatible and that can help in wound healing may be necessary for wound dressing applications. An attempt has been made to develop a composite film from chitosan by incorporating chitin nanobibres to improve its tensile strength and elasticity. Nanocomposite films were prepared from chitosan by solution casting after incorporating chitin nanofibres as nanofillers. Its mechanical strength, swelling characteristics and water vapour transmission rates were studied.