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Water Status Detection By Free-Dipping Method Using Chitosan Based Sensor

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ABSTRACT

A film sensor based on chitosan that is capable to evidence the different water status has been successfully fabricated by an electrochemical deposition technique. Main objective of this study is to utilize the chitosan as an advanced sensing material to detect the water’s conductivity. The presence of amino group in chitosan molecular structure has enabled the chitosan film sensor to detect the water’s conductivity by a novel free-dipping method. The result showed that the output voltage of chitosan film sensor was in range of 190 to 206 mV upon exposed to the river water. For the exposure of drinking water, the output voltage was 120 mV and when exposed totreated water, the output voltage was in the range69 to 72 mV.While the exposure of aquadest, the output voltage of chitosan film sensor had the value from 121 to 134 mV. Therefore, the chitosan film sensor was able to show a different output voltage values for each type of water sample.

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INTRODUCTION

Most conventional method to monitor water status is relied on gravimetric and conductivity. The disadvantage of gravimetric method is time-consuming by requiring a complicated calibration, while conductivity method still has low accuracy (usually around 10%) [1,2]. The methods also use the dipping process, meaning that there is direct contact between the sensitive layerand object that monitored whereinthis can cause the difficulty for maintenance and to find reliable data. The alternative methods are to be very important to be obtained as an effort to solve the problems.

We evidenced that chitosan-based sensors have good electrical properties in sensing the presence of water molecules [3]. They also described the sensing mechanism of chitosan based sensor to water molecules in terms of the interaction between water molecules and amino group of chitosan. Therefore, it is interested to investigate the electrical properties of chitosan based sensor for detecting the water status in this study. The properties which include sensitivity, response, recovery, reproducibility, repeatability and stability were used to show the great potential of the sensor in detecting the water status by the novel free-dipping method..

MATERIAL AND METHODS

Materials and Sample Preparation:

Chitosan powder (Sigma Aldrich, 99.9%) of deacetylation of chitin from crab shells was used as the sensing material. There are several stages for the fabrication of chitosan film sensors. First, the chitosan powder was dissolved into 2% acetic acid by stirring it for 24 hours in room temperature to obtain homogeneous solution of chitosan. Second, this solution was deposited onto the surface of the PCB substrate with an electrochemical deposition method as shown in Fig. 1. Furthermore, the wet chitosan film of dyeing was dried in a vacuum oven.

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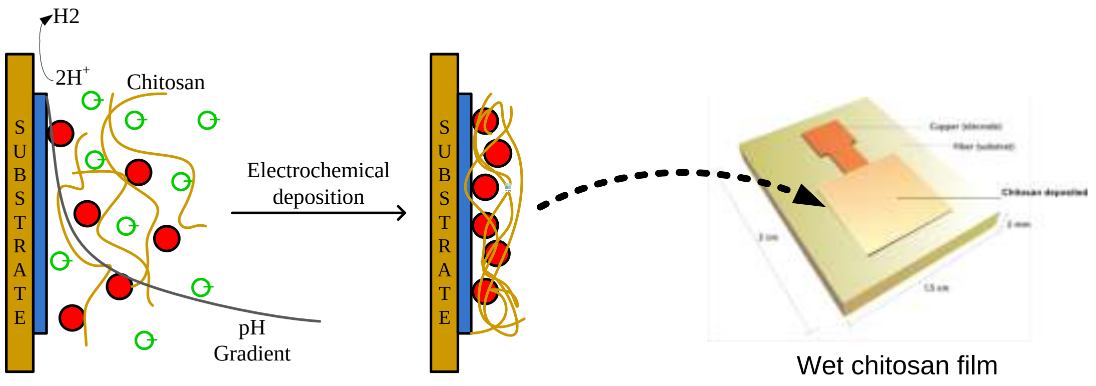

Fig. 1: Chitosan coating process with electrochemical deposition method

Electrical Measurement:

The electrical testing of the chitosan film sensor properties is in accordance to the experimental setup diagram as shown in Fig. 2. In operation, the sensor was placed in a testing chamber associated with a tube containing silica gel (called as a drying tube), tube containing water sample (called as a test tube) and air pump. The chitosan film sensor detected the concentration of dissolved solids in water sample was indicated by the increase in output voltage of the sensor.

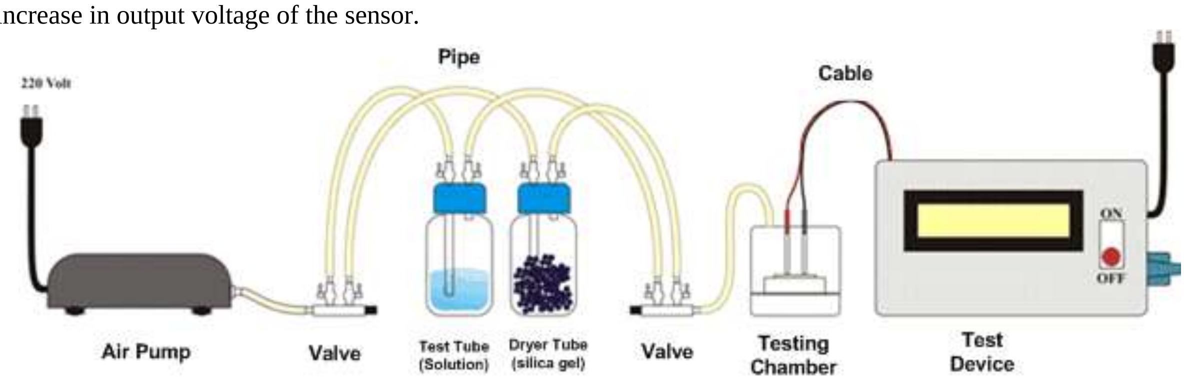

Fig. 2: Electrical testing of sensor properties scheme.

Microstructure Characterization:

The microstructure characterization of the chitosan films was performed using Scanning Electron Microscopy (SEM) to see the sensor's surface morphology. This was done before electrical testing, to ensure that the chitosan films are well formed and fit to be tested. The characterization results were then related to the results of electrical testing to determine the sensor's performance.

RESULTS AND DISCUSSION

Morphology analysis:

Scanning electron microscope image in Fig. 3 shows the physical of chitosan film coated onto a patterned copper layer. It can be clearly seen that chitosan film has very close particle arrangement which is an advantage for electrical conduction at low temperature. When the water sample vapour is exposed to the chitosan film surface, the hydrogen bonds of water molecules can form the conductive pathway readily because the pores of chitosan film are very small. We believe that the condition has contributed to the fast response of chitosan film sensor upon exposed to water molecules.

Electrical properties:

Figure 4 shows the chitosan film sensor's response as a function of time, indicated by the increase in output voltage of the sensor when its surface was exposed to different water samples. Chitosan film sensor has fast response time, around 10 seconds, for three times exposures for each sample. It was shown that the sensor has the output voltage of around 190-206 mV upon exposure with the river water. While the exposure with drinking water, the sensor showed the output voltage of around 120 mV. For the exposure of treated water and aquadest provided the output voltages of around 69-72 mV and 121-134 mV, respectively. The sensor reaches the saturation condition or the maximum output voltages at around 206, 134, 120 and 72 mV for the exposure of river water exposure, aquadest, drinking water and treated water, respectively. When the exposures are removed for 3 minutes, the maximum output voltages of the sensor drop to the initial values which indicate the chitosan film sensor has complete recovery. The increase and decrease in output voltages show the same trend and occur for all different water samples and for three time exposures, meaning that the chitosan film sensor has good repeatability. No significant fluctuations in output voltages during the exposure and recovery evidence the chitosan sensor worked in stable condition.

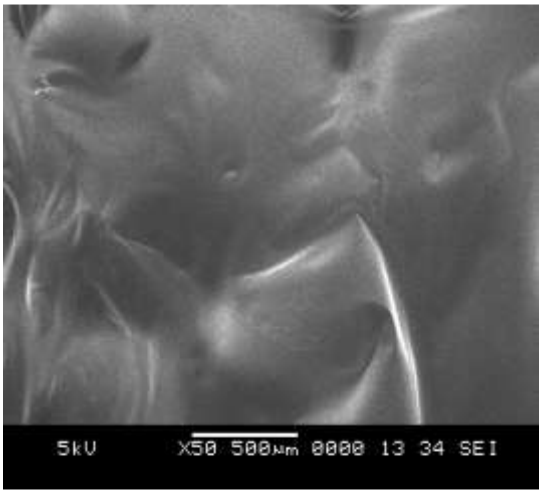

Fig. 3: Image of chitosan film deposited onto copper layer.

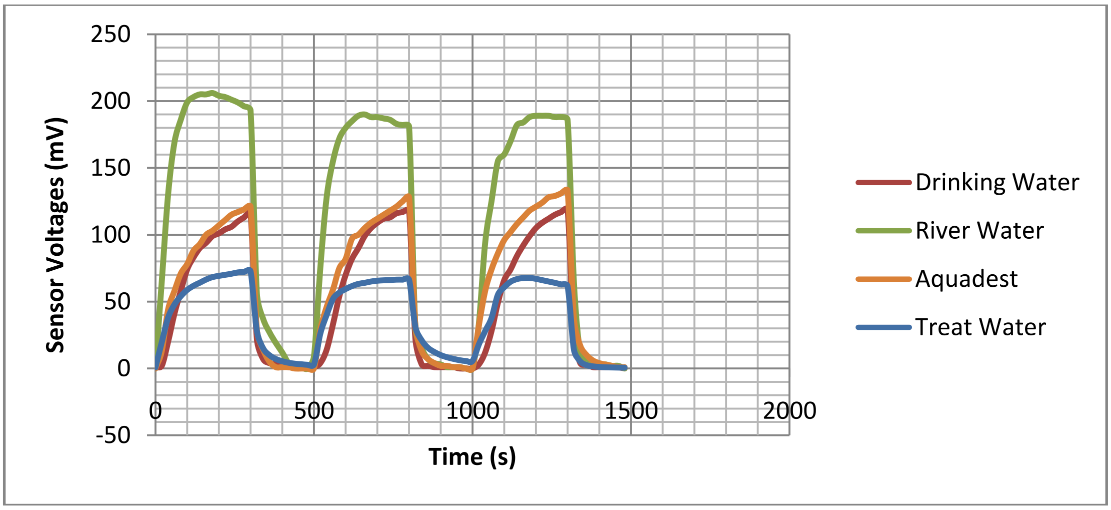

Fig. 4: The response of chitosan film sensor to different water samples.

Conclusion:

In this study, chitosan film sensors have been successfully used to differentiate the water status consisting of river water, treated water, drinking water and aquadest. During the testing, the sensor operated at room temperature with desired electrical properties including fast response, complete recovery, good repeatability and good stability. The advantage of the sensor's properties shows that the chitosan film has high potential for practical water status detector.

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