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HIGH RESOLUTION FIBER OPTIC PH SENSOR WITH INDICATOR DYE IMMOBILIZED IN POLYANILINE CLADDING

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ABSTRACT

Optical pH sensors offer a promising alternative over the existence electrochemical and other pH sensors due to the ability to achieve high performance, electrical passive operation, simplicity and price effectiveness. Recently, significant research efforts have been devoted to pH sensors for the detection of pH variation in high resolution and pH change over a small range. It becomes important to consider ways to improve the sensitivity of the sensor by improving both the properties of the material and simple method of sensor fabrication. Effort has been put in studying the fabrication and the sensitivity of active thin film towards pH range in physiological applications. Most optical sensors consist of an indicator which is immobilized in a glass or polymer matrix. In this research, polyaniline act as a sol - gel matrix to support pH sensitive indicator molecules which are bromothymol blue and phenol red. Polyaniline has been found to be versatile functional material which is the most suitable organic material to act as a matrix in liquid and has the capability to sense pH changes optically. The combined optical properties of polyaniline and bromothymol blue or phenol red will enhance the sensitivity of the sensor. The sensing capabilities of the device in term of its optical absorption intensity with different pH values were explored. Besides that, simpler and low-cost method was adopted and developed. The two indicators were doped separately in polyaniline sol-gel and deposited by dip coating on planar substrate for process optimization before deposited as cladding on a portion of fiber optic. Sensor performance were observed to be affected by several process parameters including concentration of dye, number of deposition layers, drying duration, withdrawal speed and length of re-cladded portion on the fiber. Through the final investigations, it was found that sensor fabricated using polyaniline thin film loaded with 1.5 mg/ml of bromothymol blue, deposited for 4-layers at withdrawal speed of 20 mm/s over re-clad length of 0.5 cm and dried for 24 hours produced the best sensor performance. This sensor with polyaniline thin film of thickness 285.4 nm having a sensitivity and linearity of 0.00818 au/pH and 0.8525 respectively. For sensor fabricated with phenol red of 2.0 mg/ml, deposited for 4-layers at withdrawal speed of 15 mm/s over a re-clad length of 0.5 cm and dried for 5 hours produced a polyaniline thin film with thickness of 88.46 nm having a sensitivity and linearity of 0.0585 au/pH and 0.9468 respectively. Research findings reveal that the sensing species are probably better doped in the matrix minimizing leaching of sensing molecules as shown from the repeatability result. A repeatable response over a range of pH values between 4 and 10 for every 0.2 pH resolution is obtained. Furthermore, the prepared sensor exhibits better response for detection of high resolution pH which is 0.2 pH unit.

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CHAPTER ONE
INTRODUCTION

1.1 RESEARCH BACKGROUND

Many types of pH sensor are easily available in commercial market like pH strips, indicator reagent and amperometric or potentiometric device are the most commonly used [1]. The earliest chemical indicator of pH measurement is pH strips or litmus paper and is still in use for laboratory activities at school. Conveniently used in simple applications, the colour of litmus paper between blue and red might be used to determine variation in pH. However, it suffers certain limitation on fulfilling to test at some point and unable to use in high accuracy cases [2]. Then, the first commercial pH meters were invented around 1936 by Arnold Beckman consisting of glass electrode, reference cell and electrometer [3]. The pH meter will produce a small voltage and converted to pH units. However, this electrochemical device has several problems including electromagnetic interface interfering with each other and cause degrading efficiency and performance of device [4].

In the recent years, optical method has been introduced and investigated to be successfully used as sensors and in some cases its performance surpassed the other electrochemical sensors [5-7]. The unique feature about this technique is application on fiber-based devices to act as remote sensing to produces the spectral characteristics. Besides that, optical devices are suitable for harsh conditions, ability to achieve high-performance, electrically passive operation, freedom from electromagnetic interference, multiplexed detections [8], continuously detection [9], large dynamic range, simplicity and cost effectiveness [6]. Now, optical pH sensor is the preferred choice for applications over conventional pH sensor and extensively development for many physiological applications such as brain pH monitoring, blood pH monitoring and gastric pH sensing. Peterson is the first person to introduce and develop fiber pH sensors to measure blood pH in human body in 1980 [10] encouraging many other researchers to continue on this investigation.