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ChemTech

International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN : 0974-4290
Vol.6, No.6, pp 3325-3327, Aug-Sep 2014

ICMCT-2014 [10th – 12th March 2014]
International Conference on Materials and Characterization Techniques

Sensitivity Study of Cladding Modified With Polyaniline Immobilised Glucose Oxidase Intrinsic Fiber Optic Glucose Biosensor

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Abstract: In the present investigation, the polyaniline, a conducting polymer has been synthesized from aniline monomer by chemical polymerization method at a room temperature and coated it on a cladding removed portion of optical fiber by submersing cladding removed portion in the solution during the process of polymerisation to prepare sensing element. Glucose oxidase was immobilized on coated portion through cross linking via glutaraldehyde. Sensitivity of developed sensing element toward glucose has been studied by measuring optical intensity at the output. The surface morphology of the sensing element has been studied by scanning electron microscopy.
Keywords: Conducting polymers; polyaniline; optical fiber; biocomponents.

Introduction:

As reported by Mac Diarmid and Epstein, polyaniline (PANI) - a conducting polymer may be deposited on substrates such as fibers, textiles, glass, gold, etc. and it can be used for chemical and biological sensing [1]. The researchers in the field of biosensor have developed biosensor using conducting polymers to enhance speed, sensitivity and versatility in diagnostics of vital analytes. Conducting polymers provides a suitable matrix for the entrapment of enzymes [2]. Moreover, the polymer itself can be modified to bind protein molecule [3, 4].

There are various types of biosensors, useful in many fields but have found number of advantages in the fiber optic biosensor system [5]. The fiber optic based biosensors can be prepared by using cladding modification approach, means its sensing element is prepared by replacing few centimetres of passive cladding with active cladding such as with conducting polymer, enzymes, etc. The sensing element modifies the various properties of light passing though optcal fiber after bringing it in an environment of analyte. Conducting polymers such as polyanline, polypyrrole, polythiophene, polyindole, etc. have been considered as the material for immobilization of bio-component and provides good porous matrix for entrapment of enzymes [6, 7].

In the present investigation, the cladding modified with PANI, glucose oxidase (enzyme) immobilized via cross-linking with glutaraldehyde fiber optic glucose biosensor (FOIGB) has been developed to detect

glucose (analyte). The sensing response of the sensor has been studied.

Experimental:

The chemicals aniline and ferric chloride (Fisher Scientific, Mumbai), glucose oxidase (GODx) (125Units/mg), glucose, glutaraldehyde solution and acetone (sd Fine chemicals, Mumbai) of analytical grade were used without further purification. UV-visible (UV-vis) study was carried out on a portable UV-vis fiber optic spectrophotometer (StellarNet BLK-C-SR, USA) in the wavelength range 200-1000 nm. The field emission scanning electron microscope (FE-SEM) images were taken with a scanning electron microscope (Hitachi S-4800, Japan), operated at 15.0 kV. The sensing element was sputter-coated with a thin layer of gold prior to the SEM examination. CCD camera beam profiler (Thorlab, USA) was used to measure sensing response.

The ends of one meter long plastic cladded optical fiber (core/cladding-960/40μm) were polished and SMA905 connectors were attached. Cladding of 2cm portion was removed and submerged in aniline solution, and $FeCl_3$ solution was added drop by drop in it with constant stirring to deposit a thin layer of PANI on cladding removed portion during polymerization. After 12 minutes, cladding modified with PANI FOIGB was formed. Then it was dried for one hour at room temperature and washed several times with distilled water. The stock solution of enzyme-GODx prepared in 0.1M phosphate buffer of pH 7.4 was immobilized on sensing portion by cross-linking via 1% glutaraldehyde solution to overcome leaching problem [7] and left for 30minutes. After washing it 2-3 times with phosphate buffer solution, it was ready to sense glucose. He- Ne laser (λ -632.8nm. power-1Mw) was at one and output power was recorded at other end.

Results and Discussion:

The recorded UV-vis absorption spectra of PANI film in the range 200-1000 nm is as shown in Figure 1. A brown coloured film shows two absorption peaks at 272 and 732 nm. These peaks may be attributed to the π-π* transition and bi-polaron charge transfer band of PANI film, respectively [1].

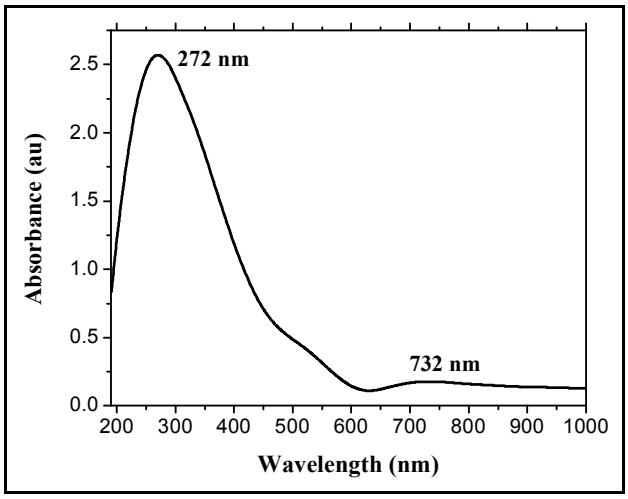

Figure 1 UV-vis spectrum of PANI.

The surface morphology of the sensing element after PANI deposition but prior to enzyme immobilization was carried out by FE-SEM as shown in incent of Figure 2. From it may be conclude that polyaniline offers the porous and cauliflower like matrix for the immobilization of enzymes. This matrix certainly enhances the sensitivity of the biosensor, because it can entrap the biocomponent/enzyme easily and can hold it for longer duration with improved stability of the sensor.

Figure 2 also depicts the sensing response of FOIGB for 7.4pH phosphate buffer, 10mM and 100mM glucose solutions. For buffer solution, there is no change in power but the glucose solutions (10mM and 100mM concentrations) inserted in solution container, the power increases with increase in concentrations. The increase in optical power at the output of FOIGB certainly may be due to the reaction between glucose oxidase and glucose taking place at the surface of sensing element. The variation in refractive index takes place at outer layers, changes the number of leaky modes coupled back to the sensing element.

From the study it may be concludes that, the morphology study of PANI on sensing element shows the porous nature of polyaniline thin film on fiber optic substrate. The PANI is a suitable and convenient conducting polymer for the formation cladding modification. The sensing response study shows that the prepared FOIGB by immobilizing glucose oxidase via glutaraldehyde can detect glucose. The increase in power at the output has been seen with increase in concentration of glucose.

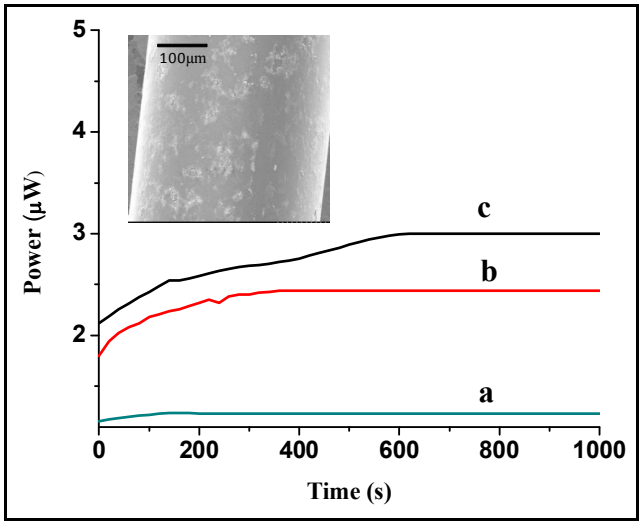

Figure 2 Sensing response of cladding modified with PANI FOIGB: (a) pure buffer solution, (b) 10mM and (c) 100mM glucose solutions.

Acknowledgement:

The authors acknowledge financial support by Defence Research & Development Organization (DRDO), New Delhi, India (Project no. ERIP/ER/1003856/M/01/1293).

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