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RESEARCH ARTICLE

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Collagen thin film glucose biosensor

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Abstract: A biosensor is an analytical device, used for the detection of an analyte that combines a biological component with a physicochemical detector. Here the biosensor using chrome shavings, chrome containing leather waste in tannery, based collagen from tannery solid waste is characterized for bio sensing application such as glucose detector. The electrical and electronic characteristics obtained using cyclic voltmeter (CV) reveals, the sensitivity of 2μA/V/gm Zinc oxide nanoparticles and 2 mA/V / 1.5gm. We prepared two solutions of glucose i.e., 3mM and 17 mM. The resulting voltage for concentrations below 4 mM (70mg/dL) hypoglycemic or above 10mM (180mg/dL) is considered to be hyperglycemic respectively. The voltage for these concentrations recorded was 270mV (70 mV/mM) and 860mV (86 mV/mM). After approximately 5 seconds the solution was placed on the ZnO collagen glucose sensor the voltage peaked at 270mV for the 3mM glucose solution and 860mV for the 17mM glucose solution. Thus, using the byproduct of tanning industry, a biosensor can be fabricated for biomedical application.

Keywords: Chrome Shavings from leather waste, Collagen, Biosensor, Biomedical application.

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INTRODUCTION

India is generating 94 million pieces of leather pieces of variable sizes per annum, out of this 20% is wasted in various leather goods industries. The aim of this study is to recycle the leather wastes and make it into a value added bio product. Zinc oxide nanoparticles have received considerable attention due to their UV filtering properties, high catalytic, photochemical activity, electrical and electronic properties. An attempt is made to synthesize and characterize zinc oxide nanoparticles to be used for applications in electrical and electronics industry. The characterization of the nanoparticles is carried out using analytical techniques such as the Fourier Transform infrared spectroscopy (FTIR) and the Fourier Transform – Raman spectroscopy. The availability of a wide range of nanostructures makes zinc oxide nanoparticles an ideal material for Nanoscale optoelectronics, piezoelectric and nanogeneration as well as efficient material for electrical & electronic industry. Presently, there is an increasing demand for the development of nano sized semiconductors due to their significant electrical, electronic and optical properties which are highly useful in fabricating Nanoscale opto electronic and bio electronic devices with multi functionality. Collagen thin film sheets coated with zinc oxide nanoparticles are very promising for various applications, such as nano generators, and photo catalysts. In the present study, we have reported the synthesis of zinc oxide nanoparticles using Ethylene glycol medium. The ZnO nanoparticles are incorporated in thin collagen films and characterized and studied for its bio sensing ability.

Methodology

Preparation of zinc oxide nano particle in aqueous medium

5.5 gm of Zinc Chloride is dissolved in 100 ml of distilled water and heated up to 90°C. A beaker containing zinc chloride, 16% sodium hydroxide solution is added to the zinc solution and stirred for 2 hours. The supernatant is solution removed using the pipette while the colloidal solution (bottom layer) is washed 5 times with distilled water, the washed sample is taken and dried at a temperature of 100°C for 30 minutes, this yields a powder of ZnO nanoparticles. Figure 1(a) shows the basic biosensor, Fig 1(b) shows the reading taken using a mutimeter [ORPAT make] for the analyte – glucose Oxidase dispersed on the biosensor using chrome shavings based collagen from tannery solid waste impregnated with the ZnO nanoparticles which acts as an impediometric biochemical transducer.

Biosensor Principle

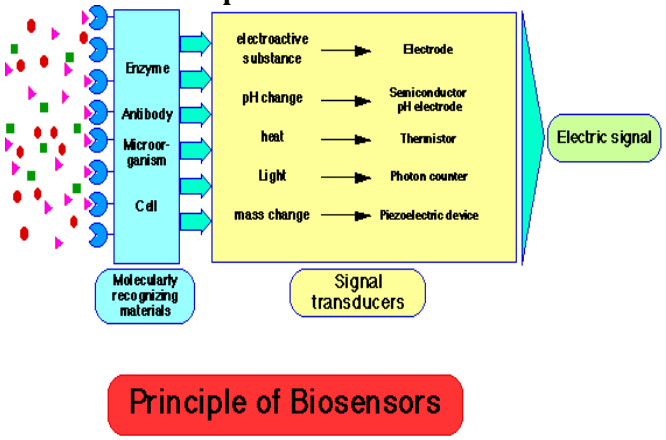

Figure.1. Basic biosensor model

Prototype Model

Figure .2 Collagen ZnO NP thin film Biosensor

Figure 2.Shows the collagen thin film and electrodes embedded with glucose oxidase

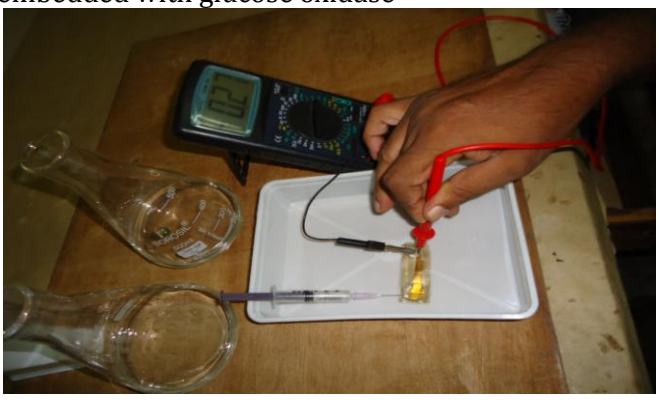

Figure.3. (a) Basic biosensor model

Figure. 3. (b)

Figure.1, 2 shows the basic biosensor Figure.3(a),(b) shows the voltages for the analyte – Glucose oxidase on collagen biosensor for hypo and hyper glycemic levels.

Experimental methods

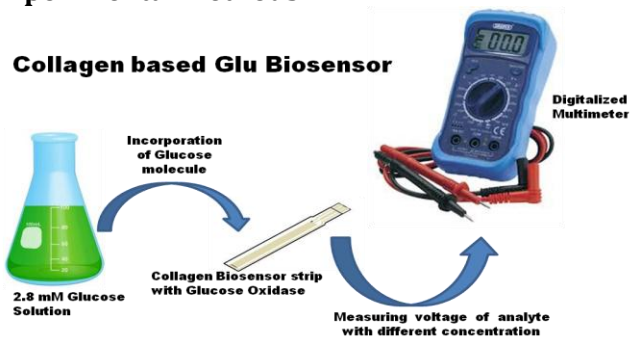

Figure 4 shows the experimental methodology applied.

Block diagram

Flowchart of biosensor using ZnO NP

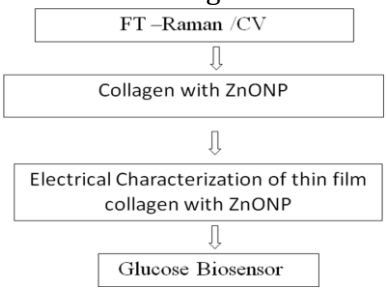

Figure. 5: Block diagram of the experimental set up

The experimental method used to characterize the presence of ZnO nanoparticles in the medium used, impregnated with the collagen thin film. The cyclic volt meter reading confirm that the collagen film with the electrodes used in this experiment (Copper and Zinc) with the ZnO nanoparticles acts as an impedimetric electrochemical biosensor transducer (glucose).The graph indicates that the voltage against the current for the sample used is having voltage of 95 milli volt per mM of the analyte.

Results and Discussion

The absorption peaks are obtained at 436cm-1, 878cm-1, 1088cm-1, 1402cm-1, 1634cm-1, 2937cm-1, 3430cm-1. The peaks at 436cm-1 corresponds to zinc oxide nano particles. The spectrum obtained for Ethanediol (Ethylene glycol) also has the absorption peak at 437cm-1s.

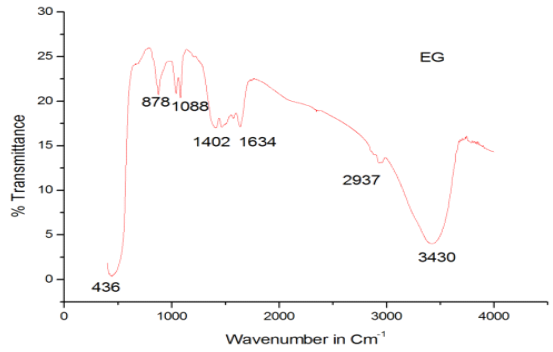

Figure.6.shows the FTIR spectra for the ethylene glycol medium.

The absorption occurs at 438 for the medium in ethylene glycol.

No. of Samples	Tensile Strength (Mpa)	Elongation At Break (%)	Thickness(mm)
1.	24.11	5.80	0.16
2.	29.48	12.50	0.10

Table.1 Mechanical properties of the thin films of collagen based zinc oxide nanoparticles

In our study the material exhibits the desired thickness and good tensile strength as in the table 1.

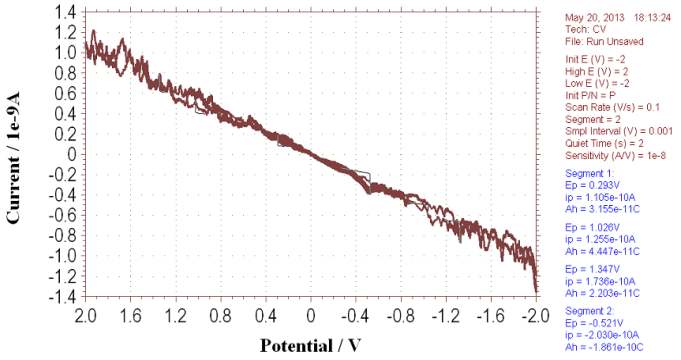

Figure.7. Result of cyclic voltmeter (0.05g)

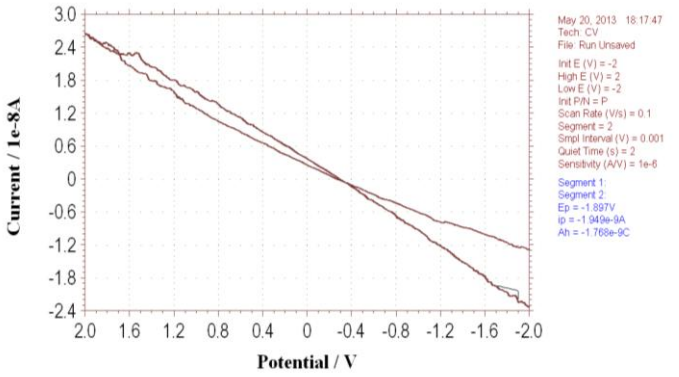

Figure.8. Result of cyclic voltmeter (0.07g)

The repeated occurrence of the peak at the desired wavelengths for both the medium the study further reveals an increase in current as the concentration of zinc oxide nanoparticle is increased.

Conclusion

In this study the Zinc Oxide Nanoparticles and Collagen based thin film Sheet generates current of 4 µA and voltage of 4 mA, Also shows that as the concentration of the zinc oxide nano particle increases there is a marginal change in the current output. The resulting voltage of Biosensor strips for the experiments in response to the 2.8mM solution and 16.7mM solution are recorded. The voltage peaked at 280mv for the 2.8mM solution (hypoglycemia) and 860mv for the 16.7mM solution (hyperglycemias) shows 9.4 mV per mM solution.The solution of higher concentration resulted in a higher spike in voltage. This biosensor is made as a bench scale model and further standardization and calibration is to be repeated for

pilot scale production. The accuracy of the reading is less than 0.2 % error. The product is cost effective and further it can be reduced when it is made in a large scale. The market price of the product is rupees 45, our price will be rupees 20.

In this study, we not only reduce the environmental pollution but also recycle the waste leather into the value added product, which helps in "Green and Advanced Technology for the Environment Sustainability [GATES]"

Acknowledgement

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