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A NOVEL GLUCOSE BIOSENSOR

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Abstract: The enhancement of electrode efficiency for glucose biosensor have been playing a vital role in the medical field, particularly in monitoring the blood glucose level of a person for control and treatment of diabetes. Hence, Titanium dioxide (TiO_2) nanoparticles possess larger surface area, greater stability, greater sensing ability, uniformity and good biocompatibility, it could enhance the electrode efficiency in the application of glucose bio sensor. Furthermore, the modification of TiO_2 together with graphene on electrode shows effective sensing of glucose compared to normal bio-sensing of glucose. In this article, we discuss about how the electrode efficiency of glucose biosensor can be improved by the diffusion of TiO_2/ graphene on its electrodes surface, with the analysis from electrochemical technique in the form of CV characteristics.

Keywords: **Electrodes, Biosensors, Monitors, TiO_2-GR composite, Characteristics.**

I. INTRODUCTION

Nowadays, there are so many researches have been arising in medical, industrial, electrical, electronics, biology, physics, chemistry and in different form of sectors, which are majorly based on the field of Nanotechnology. As, the nanofield got the enomorous properties to improve the efficiency of the existing macrolevel or nanolevel systems and it has being done by reducing it sizes to the nano level. But, the world of researches is majorly running on biomedical field, in treating and controlling the curious diseases, such as cancer, diabetes etc,. and developing new medicines to treat those diseases. Among all, diabetes is a worldwide widespread disease affecting million people, and is predicted to be the seventh leading cause of death if the current morbidity trends continue. It may give severe damage in some body parts like neurological and nephrological damages. So, it is essential to carry out researches to predict, control and to cure diabetes in a quickest way. The very actual way of predicting the diabetes is by knowing the level of glucose in our body system and there are many methods like electrochemical technique, surface plasmon resonance technique and colorimetric technique to carry out glucose detection. Among all, electrochemical technique is most preferable as we have operate in a lower range detection of sample and also it is cost effective. The reason why we are choosing Titanium Dioxide and Graphene oxide in detection and analysis of glucose has been cleared with the following words.

Titanium dioxide (TiO2), is a good known for its physical and chemical properties when using it in all kind of application. Because of its major properties like larger surface area, photo electric activity, greater stability and good bio compatibility (1) adsorption edge energy, efficient separation of the charge carriers, crystallite size (2), high sensitivity, selectivity in the field of photo electrochemistry detection (3), high reactivity under ultraviolet light (<387 nm)(4), biological inert nature and high electronic mobility (5), TiO2 is used in many researches which includes nano, micro and macro level. Lot more researches are continuously going on to learn more about its properties and to provide good outcome or efficiency in an application. On the other hand, if we are switch over to graphene, it possesses some overwhelming optical, mechanical, electrical and thermal properties. Though graphene sheet is being good in so many applications, it is non soluble and non-fusible in limited applications. So, we are leading our research with graphene oxide obtained from graphite powder by exfoliating with strong reduction agent and it can be synthesised either by chemical or thermal reduction. It can be produced in a large scale at low cost and it also used in large scale application in the form of charge extraction layer, active layer and electrodes. Graphite oxide or graphene oxide (GO) can be described as a single layer of graphene and have oxygen functional groups in its basal planes and edges. Hence, the functionalization of GO or chemical modification of these functional groups, could lead us to extend our researches in many other applications and it includes electrochemistry, as those modifications could tune its physiochemical properties (46). Although TiO2 has good electron transport layer, it may also have some issues like grain boundary scattering. To facilitate electron transport, we may modify the TiO2 structure by adding another efficient element in to it. Henceforth, we have combining Titanium dioxide (TiO2) and Graphene oxide (GO) to get good efficiency in this application. In this paper, TiO2 GO composites were synthesized via AASA (aerosol assisted self assembly) process and its led us to make an efficient electrochemical sensor. The electrocatalytic ability and super conductivity properties of TiO2 GO composites would help us to detect glucose in an efficient way with help of electrochemical technique in the form of cyclic voltammetry analysis.

There are three main parts of a biosensor: i) the biological recognition elements that differentiate the target molecules in the presence of various chemicals, ii) a transducer that converts the bio recognition event into a measurable signal , and iii) a signal processing system that converts the signal into a readable form[19-21]. Enzymatic amperometric glucose biosensors are the most common devices that are commercially available. Amperometric sensors monitor currents generated when electrons are exchanged either directly or indirectly between a biological system and an electrode [22-27].

II. MATERIALS AND METHODS

2.1. Preparation of Graphene Oxide

Graphite oxide is a yellowish solid compound typically made up carbon, oxygen and hydrogen. When it is used to form unimolecular sheets it is called as graphene oxide. By using modified Hummers process collodial Go is prepared by the oxidation of graphite powder. First the pre-oxidation process is carried out in an oil bath at 80°C by stirring graphite, $K_2S_2O_8$ and H_2SO_4. Next the oxidation process is carried in an oil bath by adding $KMnO_4$ slowly at 30°C. The mixed solution is transferred to an ice bath to form a thick paste. Then at a temperature below 50°C distilled water is continuously added and stirred for 30 min. In the final stage water is added to the paste till the color of solution changes from dark brown to yellow. The warm colloidal mixture is then filtered, washed with distilled water and dried. With mechanical agitation or mild sonication the dried GO was redispersed in water using a table-top ultrasonic cleaner thus forming a collodial solution of exfoliated GO.

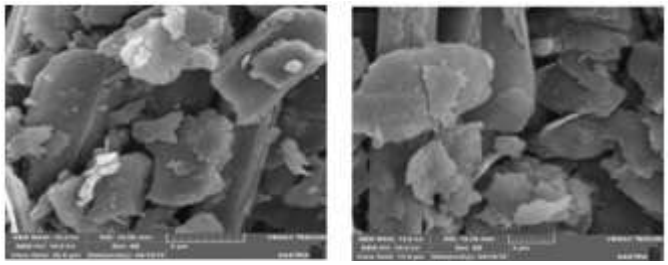

Figure. 1: SEM image of GO

2.2. Synthesis of Titanium dioxide

The Titanium tetra chloride (TiCl4) was used as a starting material in this synthesis 50 ml of TiCl4 was slowly added to the 200 ml distilled water in an ice cool bath. The beaker was taken from the ice bath to room temperature. The beaker was kept in magnetic stirrer to make a homogeneous solution for 30 minutes. Bath temperature was raised to 150 degree c and kept in the same temperature till the process of nano particle was completed.

In another vessel 26 grams of urea was dissolved in 250 ml of distilled mater. From the vessel 150 ml of urea solution was added to beaker under constant stirring, drop by drop touching the walls of the beaker. The solution turned into white colloid without any precipitation, after the complete reaction, the solution was allowed to settle and the solution was washed with distilled water for 5 times.

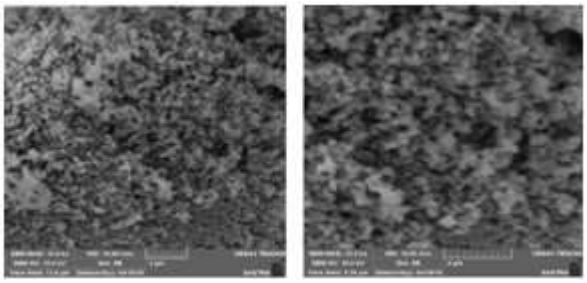

Figure.2. SEM image of TiO_2

2.3. Preparation of TiO_2- GR composite

A collodial mixture solution of TiO_2- GR composite as an aerosol precursor was prepared for the 01.05 to 2.0 with the as-prepared GO colloid and sub materials of metal oxide particles (TiO2). The concentration of TiO_2 was fixed at 0.1 wt%. A micron sized droplets of metal oxide GO is generated using ultrasonic atomizer and is carried by means of argon gas inside a tubular furnace. The GR composite formed in the furnace is collected using a Teflon membrane filter which is heated to prevent the condensation of water. Rapid evaporation of water, self-assembly between GO and TiO_2 and thermal reduction of GO is carried out in series in the furnace for the synthesis of GR-TiO_2 composite

A field-emission scanning electron microscope (FE-SEM; Sirion, FEI) was used to characterize the particle morphology and the size of the TiO2–GR composite. X-ray diffractometry (XRD, Rigaku, RTP 300 RC) was used to analyze the crystallinity of the composite. Quadrasorb Quanta chrome analyzer was used to measure the BET surface areas by N_2 adsorption–desorption isotherms. A cyclic voltammetry (CV) method using an electro- chemical interface instrument (VSP, Bio-Logics) were used to measure the electrochemical properties of the glucose biosensor. The molecular species of the composite were measured at wave numbers ranging from 1000 to 2000 cm^{-1} with an excitation of 532 nm laser by Raman spectra (Lambda Ray, LSI imensionP1). For an elemental analysis of the composite, X-ray photo electron spectroscopy (XPS) measurement was carried out using a Sigma Probe photo electron spectrometer (Thermo VG).A three-electrode cell with a GCE (CH Inc., 3 mm diameter) was used as the working electrode, a platinum foil as a counter electrode and an Ag/Ag Cl electrode as the reference electrode. The peak current had a potential ranging from –1.0 to 1.0 V at a scan rate of 50 mV/s.

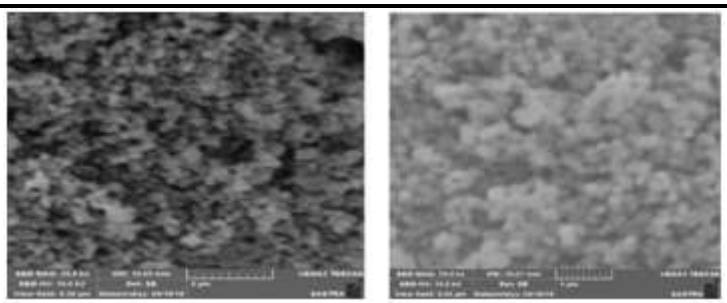

Figure. 3. SEM image of TiO_2 – GO composite

III. RESULTS AND DISCUSSION

3.1. TiO_2 and TiO_2 composite with GO based glucose sensor

Basically, the electrode efficiency could be qualitatively evaluated by using various electrochemical methods, hence the as synthesised active components have been greatly analysed by using cyclic voltammetry of electrochemical method. Thus the electrochemical oxidation of glucose was performed with different electrode material as follows: (i) bare TiO_2 (ii) TiO_2 (iii) TiO_2 /GO in the presence of 5 mg of glucose in 0.1 M NaOH at a scan rate of 50 mV/s.

As the result obtained from the cyclic voltammetry techniques shown in the Figure(4), the current response of the above mentioned electrodes corresponds to the applied potential reveals that no redox peak obtained at bare TiO_2 electrode and both reduction and oxidation curve were obtained at TiO_2 electrode.

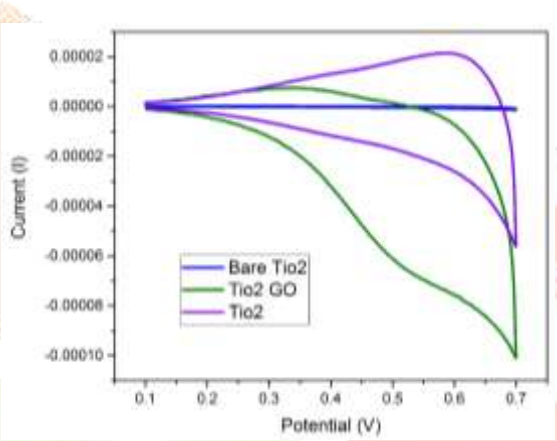

Figure.4. CVs of the electrochemical oxidation of glucose at different modified electrodes as follows: (i) bare TiO_2 (ii) TiO_2 (iii) TiO_2 /GO in the presence of 5 mg of glucose in 0.1 M NaOH at a scan rate of 50 mV/s.

But in the case of discussing about the gradual increase in the oxidation curve of TiO_2 /GO electrode, a strong oxidation peak obtained at 0.5V which is considerably lower than previous works. It reveals that the as prepared TiO_2 /GO electrode could electro oxidise glucose effectively compared to other electrodes.

3.2. Amperometric Response Analysis On Glucose Detection Over Electrode

Amperometric response has been studied with the I-T plot of the as prepared TiO_2 /GO electrode by the consecutive step changes of glucose concentration under the optimized condition.

Figure(5) shows the current Vs time plot of the TiO_2 /GO electrode response to the successive addition of glucose into the system continuously and the steady state curve was obtained from the 20 sec itself as shown.

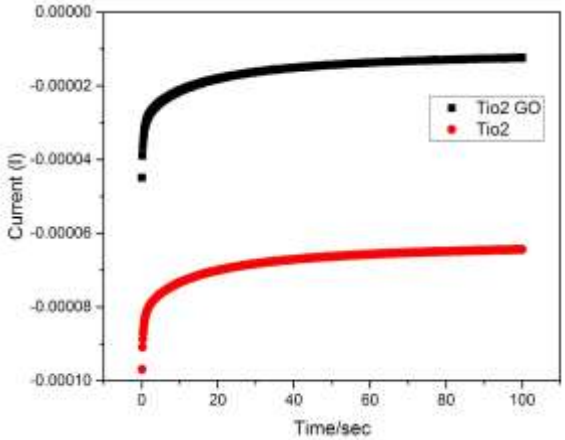

Figure.5. Amperometric response of the TiO_2 /GO electrode in 0.1M NaOH to the successive addition of glucose from 0.099-164µM. The applied potential is +0.5 V.

This linear curve was obtained only because of the addition of glucose into the system. The values of limit of detection (LOD), sensitivity and linear range could be predicted by mathematical calculations.

3.3. Evaluation of Electrochemical Impedance Spectroscopy Studies

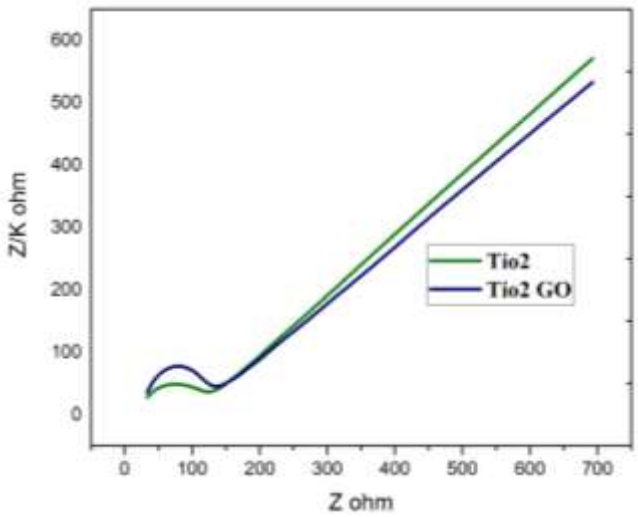

Figure. 6. The Nyquist plot for TiO_2/ GO and TiO_2 with1 the value of real component (Z_{re}) in x-axis and imaginary component (Z_{im}) in y-axis.

Electrochemical impedance spectroscopy has been done to know the electrical conductivity of our designed electrode by means of solution resistance, diffusion coefficient and charge transfer resistance between electrode / electrolyte interfaces and it is most important to know its physical properties. In other words, it could be defined as charge transfer resistance (R_{ct}) is directly proportional to the radius of the semicircle of the electrochemical impedance (EIS) curve. Hence, it could be evaluated with Nyquist plot obtained for TiO_2 and TiO_2/ GO as the value of real component (Z_{re}) in X-axis and imaginary component (Z_{im}) in Y-axis. The resultant date has been recorded with the help of supporting electrode. It shows that the radius of the semicircle obtained for the TiO_2/ GO electrode is larger than the radius obtained for the TiO_2 electrode. Hence, it proves that TiO_2/ GO electrode has higher impedance than the TiO_2 electrode in correspondence of the radius of the semicircle. Therefore, a TiO2 / GO nanocomposite systematically improves the electro catalytic property over glucose oxidation.

IV. CONCLUSION

The TiO_2- GR composite using aerosol precursor was successfully prepared. The as TiO_2 /GO electrode shows a strong oxidation peak than other modified electrodes. It reveals that the as prepared TiO_2 /GO electrode could electro oxidise glucose effectively compared to other electrodes. A steady current starts to flow at a short span after the addition of glucose. The impedance spectroscopy proves that TiO_2/ GO electrode has higher impedance than the TiO_2 electrode. Therefore, a TiO2 / GO nanocomposite systematically improves the electro catalytic property over glucose oxidation.

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REFERENCES

[1]. Jinhui F, Yueyun Li, Zengqiang G, Hui Lv, Xiaobo Z, Dawei F, Qin Wei. "Visible-light driven label-free photoelectrochemical immunosensor based on TiO2/S-BiVO4@Ag2S nanocomposites for sensitive detection OTA". Biosensors and Bioelectronic,2017. S0956-5663(17)30477-3.

[2]. Mendiola-Alvarez SY, Quzman-Mar JL, Turnes-Palomino G, Maya-Alejandro F, Calallero-Quintero A, Hernandez Ramirez A, Hinojosa-Reyes L. "Synthesis of Cr3+ doped TiO2 nanoparticles: characterization and evaluation of their visible photocatalytic performance and stability". Environ Technol. 2017. 1-10.

[3]. Madhumita B, Arjun M, Vinod Kumar G. "Synthesis and characterization of FeO/ TiO2 nano composites for ultrasound assistedenhanced catalytic degradation of reactive Black 5 in aqueous solutions". Journal of colloid and interface Science, 2017. S0021-9797(17)30783-X.

[4]. Xiaoguang Zhang, Xin Ge and Cheng Wang. "Synthesis of Titania in ethanol/ acetic acid mixture solvents: phase and morphology variations". Crystal Growth & Design, 2009. 9, 4301 – 4307.

[5]. Jin Yun Liao, Hai-Peng Lin, Homg-Yan Chen, Dai-Bin Kuang and Cheng-Yong Su. "High performance dye sensitized solar cells based on hierarchical yolk shell anatase TiO2 beads". J.Mater.Chem., 2012,22,1627.

[6]. Rahimeh Nosrati, Ali Olad, Sahar Shakoori. "Preparation of an antibacterial, hydrophilic and photocatalytically active polyacrylic coating using TiO2 nanoparticles sensitized by graphene oxide". Materials science and engineering C,2017. 80, 642-651.

[7]. Wang J., "Electrochemical Glucose Biosensor,Biodesign "Institute, Center for Bioelectronics and Biosensors, Departments of Chemical Engineering and Chemistry and Biochemistry, Box 875801, Arizona State University, Tempe, Arizona 85287-5801, Chem. Rev. 2008

[8]. Turner, A.P.F. "Advances in Biosensors", I; II; Suppl. I; III. JAI Press, London, UK, 1991; 1992; 1993; 1995.

[9]. L. Cen, K. G. Neoh, E. T. Kang, "Biosens. Bioelectron". 2003, 18, 363.

10]. Kun Zhao, Shuqi Zhuang, Zhu Chang, Haiyan Songm, Liming Dai, Pingang He, Yuzhi Fanga, "Amperometric Glucose Biosensor Based on Platinum Nanoparticles Combined Aligned Carbon Nanotubes Electrode"
[11]. Rastislav Monošíka, , Miroslav Streďanský, , Ernest Šturdíka, "Biosensors — classification, characterization and new trends"
[12]. Niraj, Gupta M.M. , Varshney H.M. , Pandey S , Singh S, "Sensors for diabetes: glucose biosensors by using different newer techniques: A review".
[13]. Maria Pilo , Roberta Farre, Joanna Izabela Lachowicz, Elisabetta Masolo, Angelo Panzanelli, Gavino Sanna , Nina Senes, Ana Sobral, and Nadia Spano, "Design of Amperometric Biosensors for the Detection of Glucose Prepared by Immobilization of Glucose Oxidase on Conducting (Poly)Thiophene Films"
[14]. Alan Pauls, Pearl Moharil, Pratyush Ravichander, Shanthi Veerappapillai," First Generation Amperometric Glucose Biosensor For Determination Of Glucose At Room Temperature Using Glucose Oxidase".
[15]. Yoo E-H, Lee S-Y. Correction: Yoo E.H., "Glucose Biosensors: An Overview of Use in Clinical Practice. Sensors". 10, 2010, 4558-4576.
[16]. Freire RS, Pessoa CA, Mello LD, Kubota LT. "Review Direct Electron Transfer : An Approach for Electrochemical Biosensors with Higher Selectivity and Sensitivity". Journal name. 14(2), 2003, 230-243.
[17]. Wang J. "Electrochemical glucose biosensors. Electrochem Sensors, Biosens their Biomed Appl". 2008, 57-69.
[18]. Hee Dong Jang ,Sun Kyung Kim , Hankwon Chang , Ki-MinRoh , Jeong-WooChoi , Jiaxing Huang "A glucose biosensor based on TiO2–Graphene composite"
[19]. Kress-Rogers, E. "Handbook of Biosensors and Electronic Noses: Medicine, Food and the Electronic Noses: Medicine, Food and the Environment", CRC Press, Boca Raton, USA, 1996.
[20]. Joseph Wang, "Electrochemical Glucose Biosensors", Chem. Rev. 2008, 108, 814-825
[15].Thevenot, D. R.; Toth, K.; Durst, R. A.; Wilson, G. S. "Electrochemical biosensors: recommended definitions and classification. Biosensors & Bioelectronics" 2001, 16(1-2), 121–131.
[21]. Kueng, A.; Kranz, C.; Mizaikoff, B. "Amperometric atp biosensor based on polymer entrapped enzymes. Biosensors & Bioelectronics" 2004, 19(10), 1301–1307.
[22]. Joseph Wang, "Electrochemical Glucose Biosensors", Chem. Rev. 2008, 108, 814-825
[23]. Madhura Nayak, Akhil Kotian, Sandhya Marathe, Dipshikha Chakravortty. "Detection of microorganisms using biosensors—A smarter way towards detection techniques. Biosensors and Bioelectronics" 25 (2009) 661–667
[24]. Ahmed Touhami, "Biosensors and Nanobiosensors: Design and Applications".
[25]. Payoshnee Bhalinge, Sourab Kumar, Abhishek Jadhav, Shilpi Suman, Pavan Gujjar, Nitesh Perla"Biosensors: Nanotools of Detection – A Review".
[26]. F.Karadeniz and A. Eksi."Sugar composition of apple juices". Eur. Food Res. Technol. (2002)215:145-148.
[27]. Md. Mahbubur Rahman, A. J. Saleh Ahammad, Joon-Hyung Jin,Sang Jung Ahn 3and Jae-Joon Lee, "A Comprehensive Review of Glucose Biosensors Based on Nano structured Metal-Oxides Sensors" 2010, 10, 4855-4886.