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 (TiO2) 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 biosensor. Furthermore, the modification of TiO2 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 TiO2/graphene on its electrodes surface, with the analysis from electrochemical technique in the form of CV characteristics.

Keywords: Electrodes, Biosensors, Monitors, TiO2-GR composite, Characteristics.

I. INTRODUCTION

Nowadays, there are so many researches have being 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 enormous 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, thermal and traditional 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 colloidal 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, K2S2O8 and H2SO4. Next the oxidation process is carried in an oil bath by adding KMnO4 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 colloidal solution of exfoliated GO.

![Figure 1: SEM image of GO](image1)

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 TiO2](image2)

2.3. Preparation of TiO2–GR composite

A colloidal mixture solution of TiO2–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 TiO2 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 TiO2 and thermal reduction of GO is carried out in series in the furnace for the synthesis of GR-TiO2 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 N2 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.
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.

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 3. SEM image of TiO$_2$ – GO composite

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.

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.
3.3. Evaluation of Electrochemical Impedance Spectroscopy Studies

Figure 6. The Nyquist plot for TiO\textsubscript{2}/GO and TiO\textsubscript{2} with the value of real component (Z\textsubscript{re}) in x-axis and imaginary component (Z\textsubscript{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\textsubscript{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\textsubscript{2} and TiO\textsubscript{2}/GO as the value of real component (Z\textsubscript{re}) in x-axis and imaginary component (Z\textsubscript{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\textsubscript{2}/GO electrode is larger than the radius obtained for the TiO\textsubscript{2} electrode. Hence, it proves that TiO\textsubscript{2}/GO electrode has higher impedance than the TiO\textsubscript{2} electrode in correspondence of the radius of the semicircle. Therefore, a TiO\textsubscript{2}/GO nanocomposite systematically improves the electro catalytic property over glucose oxidation.

IV. CONCLUSION

The TiO\textsubscript{2}-GR composite using aerosol precursor was successfully prepared. The as TiO\textsubscript{2}/GO electrode shows a strong oxidation peak than other modified electrodes. It reveals that the as prepared TiO\textsubscript{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\textsubscript{2}/GO electrode has higher impedance than the TiO\textsubscript{2} electrode. Therefore, a TiO\textsubscript{2}/GO nanocomposite systematically improves the electro catalytic property over glucose oxidation.

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