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Interaction of Glucose with ZnO Nanoparticles

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We report the results of the extent of interaction as well as the formation of a bioconjugate of glucose with Zinc Oxide nano particles (ZnO NPs) to understand the non-invasive monitoring of glucose by semiconductor NPs. We performed an array of photophysical as well as microscopic measurements to quantify the interaction between ZnO NPs and glucose. We have found that time constant of interaction (t_1) = 18.47 min for the binding glucose with surface of ZnO NPs and follows a single exponential association process.

Keywords: ZnO, Glucose, Interaction, Absorption, Exponential-association.

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1. INTRODUCTION

Diabetes describes a group of metabolic diseases in which the person has high blood glucose (blood sugar). The long term health disorders including cardiovascular disease and blindness are the outcomes of diabetes. The monitoring of glucose concentration in our blood is one of the major challenges in detection of diabetes. In spite of intensive efforts, a few methodologies are available for the non-invasive monitoring of blood glucose [1-2]. The commercial exploration of nanotechnology has accelerated the evolution of nanomaterials with many exceptional size-dependent properties for use in several areas of applied biomedical research in developing novel and improved diagnostics and therapeutics like fluorescent biological labeling to biosensors preparation.

The metallic nanostructures of gold, silver nanostructure has application in glucose testing and sensing platforms. In this communication, we report the preparation of zinc oxide (ZnO) nanoparticles (NPs) and its interaction with glucose as glucose sensing platforms. The physical basis of the interaction of ZnO NPs with glucose under conditions of environmental exposure in a better way is studied by major spectroscopic along with microscopic (HRTEM) techniques.

2. EXPERIMRNTAL

ZnO NPs were synthesized using a simple wet chemical method as reported elsewhere in [3] with minor modification. The reagents used for fabricating ZnO NPs were of analytical grade (MERCK, 99.99 % pure) and used as supplied. Under constant stirring 0.5 M Zinc Nitrate solution NaOH solution (1M) was added dropwise for 5 min and the stirring was continued further for 15 min. A white precipitate was deposited at the bottom of the flask. The precipitate was then filtered and washed 2-3 times with Millipore water for removal of any residual salts and dried in a furnace.

Glucose anhydrous (99.5 %) was purchased from HIMEDIA Chemical Co. (Mumbai).The sample was used as received without any further purification. The Glucose solution (CGLU = 1 mg/mL) was prepared by using triple distilled water, deionized with a Milli-Q water purification system from Millipore, U.S.A. The pH and the resistivity of freshly prepared water were 6.8 and 18.2 MΩ·cm, respectively. The ZnO NPs are dispersed in deionized water with concentration of Zno (C_{ZnO}) = 1 mg/mL. Finally, the colloidal solution of ZnO is mixed with glucose solution by 1 : 1 ratio. The as prepared samples are taken for optical absorption study by using Shimadzu-Pharmaspec-1700 UV-VIS. A small drop of this was dispersed sample was placed on a thin carbon film supported on the copper grid and kept for some time for drying and used for microstructural study. The Transmission Electron Micrograph of the prepared ZnO NPs was acquired using JEOL-JEM-200 operating at 200 kV. The SEAD pattern of the said NPs was also carried out.

3. RESULTS AND DISCUSSIONS

Typical TEM image of ZnO nanoparticle is shown in Fig. 1. ZnO nanoparticles of diameter ~ 10-20 nm were observed.

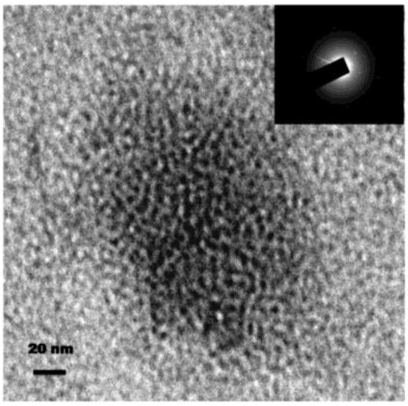

Fig. 1 – TEM image of ZnO nanoparticles. Inset shows the SAED pattern

Inset of Fig. 1 shows the SAED pattern revealing the crystallinity of the fabricated ZnO nanoparticles.

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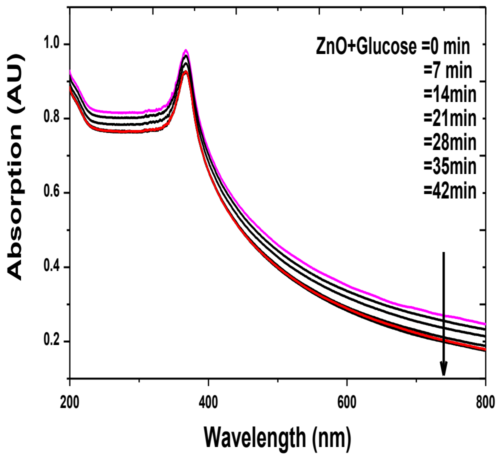

Fig. 2 – Absorption spectra of ZnO nanoparticles in glucose under different time

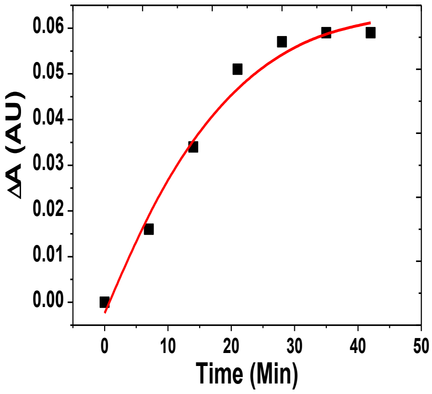

Fig. 3 – Change in absorption with time

Typical absorption spectra of ZnO NPs in presence of glucose are shown in Fig 2. ZnO NPs exhibit an absorption peak at ~ 368 nm due to excitonic transition at room temperature 28 °C. No shift of the absorption peak of ZnO is observed in presence of glucose. The intensity of the absorption of ZnO decreases in interaction with glucose.

The change in absorption intensity vs. time plot is fitted by non-linear least square fitting based on Levenberg-Marquardt algorithm of Microcal Origin 7.5 with the following exponential association equation (1) (Fig. 2) [4].

$$I_t = I_o + A_1[1 - \exp(-\frac{t}{t_1})] \quad (1)$$

Where, I_O and I_t are the absorption intensities at time zero and t respectively. The constants A_1, is the relative contribution and t_1 is corresponding time constant of mechanism involving in interaction between ZnO and Glucose. We have found that time constant of interaction (t_1) = 18.47 min for the binding glucose with surface of ZnO NPs and follows a single exponential association process.

4. CONCLUSIONS

In conclusion, we have synthesized ZnO nanoparticles using a simple wet chemical method. The results of the extent of interaction of glucose with ZnO NPs have been studied to understand the non-invasive monitoring of glucose by semiconductor NPs. The photophysical as well as microscopic measurements revealed the interaction the interaction between ZnO NPs and glucose. We have found that time constant of interaction (t_1) = 18.47 min for the binding glucose with surface of ZnO NPs and follows a single exponential association process.

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