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A Study on effect of zinc oxide and silver nanoparticles in Bio Physics

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***Abstract*- In this paper we are presented an investigation to observe the effect of zinc oxide and silver nanoparticles in Bio Physics. Nanoparticles, because of their small size, have distinct properties compared to bulk form of the same material, thus offering many new developments in the fields of biosensors, biomedicine, and bio nanotechnology. Nanotechnology is also being utilized in medicine for the diagnosis, therapeutic drug delivery and the development of the treatments for many diseases and disorders. Nanotechnology can be termed as the synthesis, characterization, exploration and application of nano-sized (1-100nm) materials for the development of science. It deals with the materials whose structures exhibit significantly novel and improved physical, chemical, and biological properties, phenomena, and functionality due to their nano-scaled size. Because of their shape and size, nanoparticles have a larger surface area than macro-sized materials. The intrinsic properties of metal nanoparticles are mainly determined by the size, shape, composition, crystallinity and morphology. The field of nanotechnology is one of the most important and active research areas in modern materials science. Nanoparticles exhibit new or improved properties based on the specific characteristics such as size, distribution and morphology. There have been impressive developments in the field of nanotechnology in the recent past years, with numerous methodologies developed to synthesize nanoparticles of particular shape and size depending on the specific requirements. New applications of nanoparticles and nanomaterials are increasing very rapidly.**

Index Terms- Size, Developed, Shape, Field etc.

I. INTRODUCTION

The history of nano materials is quite long; nevertheless, major developments within nano science have taken place during the last two decades. The idea of the Nanotechnology was first highlighted by Noble laureate Richard Feynman, in his famous lecture at the California Institute of Technology, 29th December, 1959. Richard Feynman explain in one of his articles published in 1960 titled, "There is plenty of room at the bottom" discussed the idea of nano materials. He pointed out that if a bit of information required only 100 atoms, then all the books ever written could be stored in a cube with the sides 0.02 inch long. In 1970 Norio Taniguchi first defined the term Nanotechnology. According to him, "Nanotechnology mainly consists of processing of, separation, deformation, and consolidation of material by one atom or by one molecule". And in 1980 another technologist; K. Eric Drexler promoted technological significance in nano scale. The main important thing in nano dimension is the properties of the particles are far different than bulk scale properties. Nanoparticles are being used in different fields including electrical, biological textile and chemistry in which shape and size of colloidal metal particles play crucial role in the different application including preparation of magnetic, electronic devices wound healing, anti microbial gene expression and in the preparation of bio composites. Noble metal colloids have the optical, catalytical electromagnetic properties which are dependent on size and shape of the particles. The synthesis processes for the preparation of colloidal nanoparticles with controlled morphology is crucial.

Once materials are prepared in the form of very small particles, they change significantly their physical and chemical properties. In fact in nano-dimension, percentage of surface molecule compare to bulk molecule is high and this enhances the activity of the particle in nano dimension and therefore, the normal properties of the particle like heat treatment, mass transfer, catalytic activity, etc are all increases. But compare to non-metal nanoparticles, metal nanoparticles have more industrial application. Nanoparticles offer many new developments in the field of biosensors, biomedicine and bio nanotechnology-specifically in the areas- Drugdelivery

As medical diagnostictools,
As a cancer treatment agent (Goldnanoparticles).
Nanoparticles and nanostructure are becoming a part in human medical application, including imaging or the delivery of therapeutic drugs to cell, tissues and organs. Drug loaded nanoparticles interact organ and tissues and are taken up by the cells. Several studies have shown that the tissue, cell and even cell organelle distribution (Alexiou et al., 2000; Savic et al., 2003) of drugs may be controlled and improved by their entrapment in colloidal nanomaterials, mainly of the micellar structure, such as nanocontainer. Magnetic nanoparticles have been receiving considerable attention because of their wide range of applications, such as the immobolization of the proteins and enzymes, bioseparation, immunoassays, drug delivery, and biosensors (Chen.et al., 2002). Nanoparticles of ferromagnetic materials are of importance because of their reduced sizes that can support only single magnetic domains. The recent synthesis of arrays of 4 nm diameter FePt nanoparticles with an extremely narrow size distribution has promoted a significant research effort in this area, due to their potential technological application like recording media (Varlan et al., 1996).

II. IMPORTANCE OF ZnO NANOPARTICLES

It is used in paints, cosmetics, sunscreens, plastic and rubber manufacturing, electronics, ointments, and pharmaceuticals products etc. It is also potentially used for treat leukemia and carcinoma cancercell It is also called a strong antibacterialagent It is used as drugcarrier ZnO nanoparticles is also used in the industrial sectors including environmental, synthetic textiles, food, packaging, medical care, healthcare, as well as construction and decoration.

III. ANTIBACTERIAL ACTIVITY OF ZnO NANOPARTICLES

Antibacterial agents are broadly are of two types, organic and inorganic. At high temperatures/ pressures organic antibacterial materials are found to be less stable as compared to the inorganic antibacterial agents. Thus Zinc Oxide has been proved to be a powerful antibacterial agent in the formulation of the microscale and nanoscale systems for therapeutic applications. ZnO nanoparticles have showed greater antibacterial activity apparently than micro particles. The exact mechanisms of the antibacterial action have not been yet clearly identified.
ZnO particles have bactericidal effects on the both Gram-positive and Gram-negative bacteria. They even have antibacterial activity against spores which are resistant to high- temperature and pressure. From the literature it is evident that the antibacterial activity of ZnO nanoparticles depends on the surface area and concentration, while the crystalline structure and particle have shape have little effect. Moreover, it is also mentioned in the literature that smaller the size of ZnO particles better is its antibacterial activity. Thus higher the concentration and larger the surface area of the nanoparticles, then better is its antibacterial activity. The mechanism of the antibacterial activity of ZnO particles is not still well understood. Some researchers have proposed that in their study that the generation of hydrogen peroxide is the main factor of the antibacterial activity, while it also indicated that the binding of the particles on the bacteria surface due to the electrostatic forces could be another factor. This study is an investigation on the antibacterial activity of ZnO particles against pathogenic bacterial species like Escherichia coli, Pseudomonas aeruginosa, Bacillus subtilis, and Streptococcus pneumonia. We have opted these four different types of pathogenic bacteria because the following reasons-
E. coli: Gram- negative bacteria, virulent strain causes food poisoning, urinary tract infection, neonatalmeningitis.
Pseudomonas aeruginosa: Gram-negative rod shaped bacteria infects the pulmonary tract, urinary tract, burns, wounds and also causes other bloodinfections.
Bacillus subtilis: Gram-positive coccoid bacterium causes pneumonia, meningitis, sepsis.
Streptococcus pneumonia: Gram-positive rod shaped bacteria causes food poisoning.

IV. STUDY ON THE INTERACTION OF PROTEIN AND NANOPARTICLES

The effect of the surface chemistry of biomaterials on the protein adsorption process has been a topic of great interest for many years. Protein adsorption to the various materials has been widely studied and it has been found that factors such as electrostatic interactions, hydrophobic interactions, and specific chemical interactions between the protein and the adsorbent play important roles. These interactions with the surface can easily disrupt the native conformation and therefore, the protein function. On the other hand, the conjugation of protein with nanoparticles not only allows stabilization of the system, but it is more importantly, it also introduces biocompatible functionalities onto these nanoparticles for further biological interactions or coupling.

In our present investigation α-lactalbumin has taken as a key enzyme. Although the nanoparticles and protein interaction study was a performed with few proteins like lysozyme, bovine serum albumin, β-lactalbumin, no interaction study was done with bovine α-lactalbumin. The protein is small and monomeric with a molecular mass of 14 kDa. The in vitro unfolding and refolding study of α-lactalbumin was done widely. However, it is worthy to know whether small nano level metal particles can bring any changes in its structure as well as function. Another importance of this protein is that in its intermediate state α-lactalbumin can be used as anti-turmeric agents. The same protein when form conjugate with fatty acid like oleic acid have been shown to act as anti-tumor agent.

Nanoparticles rapidly interact with the proteins present in various biological systems. However, to date, few studies have been conducted focusing on the nanoparticles that are commonly exposed to the general public, such as the metal/metal oxides. Therefore, understanding how and why proteins are adsorbed to these particles are important for understanding their biological response.

In our present investigation, we conducted an in-depth study on the synthesis and characterization of ZnO and Ag nanoparticles and their application on biological system. Antibacterial efficacy of the ZnO and Ag nanoparticles against four different bacteria like Escherichia coli, Bacillus subtilis, Pseudomonas aeruginosa, Streptococcus pneumonia has been performed. In vivo biological activity of expressed β-glucosidase enzyme in E.coli was meseared in the presence of various concentrations of ZnO and silver nanoparticles. The interaction between α-lactalbumin protein and both ZnO and Ag nanoparticles were monitored in DLS particle size analyzer to confirm the formation of protein-NP conjugate. The structural change of the protein upon interaction with NP was monitored using tryptophan fluorescence and Circular dichroismspectroscopy.

V. APPLICATION OF NANOPARTICLES

Once materials are prepared in the form of very small particles, they change significantly their physical and chemical properties. In fact in nano-dimension, percentage of surface molecule compare to bulk molecule is high and this enhances the activity of the particle in nano dimension and therefore, the normal properties of the particle like heat treatment, mass transfer, catalytic activity, etc are all increases. But compare to non-metal nanoparticles, metal nanoparticles have more industrial application. Nanoparticles offer many new developments in the field of biosensors, biomedicine and bio nanotechnology-specifically in the areas-Drugdelivery

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Magnetic nanoparticles have been receiving considerable attention because of their wide range of applications, such as the immobolization of the proteins and enzymes, bioseparation, immunoassays, drug delivery, and biosensors (Chen.et al., 2002). Nanoparticles of ferromagnetic materials are of importance because of their reduced sizes that can support only single magnetic domains. The recent synthesis of arrays of 4 nm diameter FePt nanoparticles with an extremely narrow size distribution has promoted a significant research effort in this area, due to their potential technological application like recording media (Varlan et al., 1996).

VI. APPLICATION OF ZnO

Zinc oxide (ZnO) is no stranger to scientific study. In the past 100 years, it has been produced as a subject of thousands of research papers, dating back as early as 1935. For its potential of ultra violet absorbance, wide chemistry, piezoelectricity and luminescence at very high temperatures, ZnO has entered into industry, and now is one of critical building blocks in todays modern society. It is found in the paints, cosmetics, plastic and rubber manufacturing, electronics and pharmaceuticals. More recently however, it has again gained large interest for its semiconducting properties of nano materials (Look et al., 2001).

Among this oxide nanoparticles, ZnO nanostructure material has gained much interest owing to its wide applications for various devices such as solar cells, varistors, transducers, transparent conducting electrodes, sensors, and catalysts. However, these properties of pure bulk ZnO are not stable and cannot meet the increasing needs for the present applications. In order to modify the properties of the ZnO, this semiconductor material was usually doped with some dopants like Al, Si, and Ga. For example, Al-doped ZnO increases its conductivity without impairing the optical transmission, which is regarded as a potential alternative candidate for ITO materials. (Zeng et al, 2003)

Gas sensors based on ZnO had already been developed for the detection and control of gases such as CO, H2, H2S, NH3, etc. (Zhu et al, 2005).

ZnO nanoparticles embedded in the polymer matrices like soluble starch are a good example of functional nanostructures with potential for the applications such as UV-protection ability in textiles and sunscreens, and antibacterial finishes in the medical textiles and inner wears. ZnO nanoparticles has successfully been dispersed inside a soluble starch matrix using a simple water-based technique (Joshi M.et al., 2004). The stabilization of these nanoparticles was achieved by presence of soluble starch in the reaction medium. The average size of the ZnO nanoparticles was estimated to be 38 ± 3 nm using a TEM (Vigneshwaran, 2006).

VII. CONCLUSION

ZnO and Ag nanoparticles were synthesized successfully by chemical reduction and green synthesis methods (From Citrus sinensis), respectively. The detail characterization of the nanoparticles was carried out using UV-Vis spectroscopy, Dynamic Light Scattering (DLS) particle size analysis, Scanning Electron Microscopy (SEM), X-Ray Diffraction (XRD) analysis. From Dynamic Light Scattering (DLS) particle size and SEM image analysis, the average particle size was found to be 90 nm and 50 nm, respectively for ZnO andAg. Antibacterial potential of both ZnO and Ag nanoparticles as a function of nanoparticles concentration was tested against four different bacteria like Escherichia coli, Pseudomonas aeruginosa, Bacillus subtilis, and Streptococcus pneumonia. The test was performed by both Disc diffusion assay and colony forming unit (CFU) estimation method. From the study, both types of nanoparticles were observed to have strong antimicrobial potential. When the result was compared with the effect by antibiotics like Vencomycin, Tobramycin and Erythromycin, nanoparticles were found more potent thanantibiotics. The growth study of Escherichia coli was carried out in presence of different concentration of both nanoparticles to observe the effect on the growth of the bacteria in liquid media. It was observed that both the nanoparticles strongly affected the specific growth rate of E.coli. It was also observed that the growth rate was strongly inhibited by the presence of small concentration of nanoparticles. In vivo biological activity of expressed β-glucosidase enzyme in Escherichia coli was measured in the presence of various concentrations of ZnO and silver nanoparticles. It was found that the incubation of Escherichia coli in the presence of nanoparticles caused the substantial enhancement of the biological activity of β-glucosidase invivo. In vitro interaction between α-lactalbumin and both nanoparticles were also investigated. When the binding experiments were monitored in DLS particle size analyzer, the stable protein-NP conjugate formation was confirmed. The result also helped to develop a model where multiple numbers of proteins bind to a single or multiple NP molecules. The interaction between α-lactalbumin protein and nanoparticles were also studied by tryptophan fluorescence and circular dichroism spectroscopic techniques. The tryptophan fluorescence measurement of the protein revealed the fact that the protein undergoes a havoc structural change while interacting with NP. The tryptophan fluorescence quenching study revealed that tryptophan residues are possibly in the bindingsite. Circular dichroism spectroscopic measurement confirmed the change of secondary structure of the protein in the presence of NP. Although there was no β-sheet in the native protein, binding with NP cause the formation of substantial amount of β-sheet in the protein's secondary structure.

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