CHAPTER VII

SUMMARY AND CONCLUSION

Nanotechnology broadly refers to a field of applied science and technology whose special and unique properties could be attributed to the small size and large surface area of nanoparticles. An important aspect of nanotechnology is the development of experimental processes for the synthesis of nanoparticles with different sizes, shapes and controlled dispersity. Nanoparticles, because of their small size, have distinct properties compared to the bulk form of the same material, thus offering many new developments in the fields of biosensors, biomedicine, and bio nanotechnology. The 'nano–bio' interface comprises dynamic physic-chemical interactions, kinetics and thermodynamic exchanges between nanomaterial surfaces and the surfaces of biological components (for example- small bio-molecules, proteins, DNA etc.).

Therefore in this work, we have made an attempt to explore how the metal nanoparticles of iron (Fe) and silver (Ag) can be used in biological applications such as antibiotic, antibacterial and animal study. The chemical precipitation method was chosen to synthesize iron and silver nanoparticles and the as prepared nanoparticles were systematically characterized.

In the present work, *"ab initio"* simulation studies on elemental nano-sized iron and silver particles were carried out and the results were compared with the experimental results. An attempt was made to attribute the electronic structure of the material for its effect on biological cells.

The antibacterial effects of iron (Fe) and silver (Ag) nanoparticles on different types of bacteria such as gram positive and gram negative bacteria has been studied. The prepared Fe nanoparticles were used to study the improvement of body weight, hematological parameters, hematocrit and total erythrocytic count in pig model. The prepared Ag nanoparticles were used to study the antibiotic effect on healthy rabbits which had wounds. The rate of the healing effect of the as prepared silver nanoparticles with time, on the wound of the rabbit was studied.

The Fe nanoparticles were prepared by a simple chemical method. X-ray diffraction pattern reveals that Fe nanoparticles exhibit body centred cubic structure. The average particle size of the prepared Fe nanoparticles is found to be 39.06 nm. The Raman spectrum of Fe nanoparticles has been studied and four active Raman bands were observed. The surface morphology of the prepared Fe nanoparticles has been studied using scanning electron microscope. Compositional analysis of the prepared nanoparticles has been estimated by EDAX analysis. The TEM studies show that the particle size of Fe nanoparticles is found to be 41 nm. The absorption spectrum of the as prepared Fe nanoparticles has been studied using UV-Visible spectroscopy. The prepared Fe nanoparticles will be used to study the improvement of hemoglobin content in the biological system (pig model).

Ag nanoparticles have been prepared by a simple chemical method. X-ray diffraction pattern reveals that Ag nanoparticles exhibit face-centred cubic structure. The average particle size of the nanoparticles is found to be 38.18 nm. The Raman spectrum of Ag nanoparticles has been studied and the allowed mode of Ag nanoparticles appeared at $1051 cm^{-1}$. The surface morphology of the prepared Ag nanoparticles has been studied using scanning electron microscope. Compositional analysis of the prepared nanoparticles has been confirmed by EDAX analysis. The TEM studies show that the average particle size of Ag nanoparticles is found to be 36 nm. UV-Visible spectroscopy study estimated that the particles were silver nanoparticles. The prepared Ag nanoparticles will be used to study the wound healing performance in the biological system (rabbit model).

Using the first-principle calculations, electronic structures and band parameters for Fe and Ag were obtained within the local density approximations. It is found that the structure, band gap, energy levels, band dispersion and optical properties calculated by LDA are comparable with the experimental results. The expected energy of iron nanoparticles to penetrate into the walls of the bacteria or any biological system can be estimated using this technique. It is observed that, the more the absorption energy, the more will be the permeability of the nano-material into the biological cells.

In the present study the nanoparticles of iron are subjected to have interaction with the blood medium, bacteria and enzyme. An attempt has been made to study the dielectric behavior of iron nanoparticles in blood and enzymes medium to find the factors causing the biological changes in the cell structure. The dielectric behavior of the material is necessary to know the interaction of the material with the medium or environment in which the material is present. Similar to Fe, the theoreitical calculations of Ag are found to be in good agreerment with the experimental results. Silver nanoparticles should have sufficient energy to penetrate into the cell walls of the bacteria or the biological cell structure of the animal or human. The maximum absorption energy of Ag is found as 17.5 eV which is higher than that of iron. Hence it is sufficient to penetrate into the biological cells and react with enzymes and DNA structure effectively than that of Fe. In the present study the nanoparticles of silver are subjected to have interaction with the bacteria, enzymes and body cells of rabbits.

An attempt is made to study the dielectric behavior of silver nanoparticles in bacteria and enzyme medium to find the factors causing the biological changes in the cell structure. Further, the theoritical study could be extended to probe the interactions between nanoparticles and biological systems to have a vivid understanding on the *in-vivo* or *in-vitro* studies.

Bacteria inhibition zone was correlated to antimicrobial properties of iron (Fe) and silver (Ag) nanoparticles. It is believed that the DNA loses its replication ability and cellular proteins become inactive on these metal ions. The antibacterial study clearly indicates that the iron (Fe) and silver (Ag) nanoparticles inhibit the growth of both gram-negative and gram-positive bacteria and the zone of inhibition increases as the concentration of the prepared nanoparticles are increased. It was found that the inhibition of bacteria was better for silver (Ag) nanoparticles than iron (Fe) nanoparticles under the same conditions. These results demonstrate the excellent antimicrobial behavior exhibited by silver (Ag) nanoparticles than iron (Fe) nanoparticles synthesized at a low temperature.

From the animal studies conducted on piglets, iron nanoparticle supplementation improved the weight gain and hematological characteristics. Iron nanoparticle supplementation both at 3 mg/day and 6 mg/day yielded similar effects in many aspects. Efficacy of the iron nanoparticles in preventing iron deficiency anemia in pigs was superior followed by iron dextran injection and oral ferric ammonium citrate. However, extensive study involving large number of animals may be conducted before this method is advocated to field application. Further, studies on bioavailability, organoleptic changes in meat and safety aspects including tissue residues would be valuable before recommending the iron nanoparticles for use at field level.

Studies on application of silver nanoparticles as wound healing agents, reveals that both silver nanoparticles ointment as well as solution may be used as an alternate to antibiotic cream when antibiotic resistance is suspected. However, extensive trials are to be conducted before widespread application.