CHAPTER-6

SUMMARY AND CONCLUSIONS

At cellular level the biological processes operate directly on atoms and molecules in an organized network. The aspiration of nanotechnology is also to have such perfection. Keeping the biomimicing process as standard, new and novel functionalized noble metallic nanoparticles are synthesized with self-assembly techniques using different microorganisms, plant extracts and bio-excretories as a reducing medium in this applied research. The size and shape of these bio-functionalized nanoparticles are studied using different advanced microscopic and spectroscopic techniques. Micro-architectural surface manipulations are also made to enhance the robustness, stability and functionality of existing bio-metallic nano structures.

6.1 Biosynthesis of functionalized silver nanoparticles using different microorganisms, plant extracts and bio-excretories and their pharmacological screening

We envisage here the new, simple and efficient microwave-assisted route of rapid extracellular synthesis of monodispersed, spherical shaped silver nanoparticles from different microorganisms, plants and bio-excretories. In plants, it is noticed that a chemical component, flavonoids, in guava leaf or clove buds extract are covered the surface of silver nanoparticles. The reducing sugar might have influenced in the process of formation of silver nanoparticles. Another component, ascorbates which is present abundantly in guava leaf may be adsorbed on the surface of AgNP to form a capping. It can be stated that the production of silver nanoparticles with microwave irradiation is a simple, promising process and provides an innovative methodology to Nanobiotechnology. Nanoparticles production by this method is stable for many weeks, and hence has an edge over advantage in comparison to other biological synthesis. The method is environmental friendly since no health hazardous materials are produced as byproducts. Silver nanoparticles thus produced are in a of 26 ± 5 nm size range in case of guava leaf and 30- 60 nm in clove buds mediated process. Silver nanoparticles produced in both the processes are stable for 18 – 20 weeks. The synthesis of metal nanoparticles from microwave irradiation of plant extracts will be a better alternative method to conventional, physical, and chemical and even the microbial synthesis. The simple microwave exposure process

offers a ‘clean-green’ biosynthesis of nanoparticles. As both the principle and procedure involved in this method of biosynthesis are handy; can be thought for commercial level of production. The patented investigation involves the new method of synthesis of silver nanoparticle using different types of milk and milk preparations and characterization of these particles using various advanced analytical techniques.

As explained above, the bio-synthesized AgNP carry wonderful results when used as antibacterial alternatives. The application of these silver nanoparticles in various fields such as making medical devices and pre-formulation as antimicrobial systems in pharmaceutical research will promote for many innovative discoveries.

6.2 Biosynthesis of functionalized gold nanoparticles using different microorganisms, plant extracts and bio-excretories and their pharmacological screening

Rapid synthesis and excellent reproducibility of gold nanoparticles through the plant extract mediated process has a time saving advantage over microbial synthesis and the laborious and lengthy procedures involved with them. Based on the advantageous properties offered by gold nanoparticles, innovative discoveries in the pharmaceutical pre-formulations research and the development of medical devices can be thought of. Gold nanoparticles biosynthesis may open new avenues in pharmaceutical chemistry, bio-medical and material science, nanobiotechnology and biotechnology fields. It will be helpful in future if exact mechanism of biosynthesis is understood and the methods to have control in nanoparticles production to the required size and shape with absolute monodispersivity and worked out.

We infer that from both the cases of guava and clove extracts, the freely water soluble flavonoids are responsible for the biosynthesis and stability of polyshaped and highly unpredictable amoebic type irregular shaped nanoparticles in aqueous medium. The advanced microwave technique and modest maceration process in the respective studies offer a 'clean-green' biogenesis of nanoparticles for mass production. As both the principle and procedure involved in this approach are useful; it can be thought for the progressive industrial scaling. Relevant efforts are being made to tailor the polyshaped and

irregular shaped nanoparticles bio-chemically to cater the needs of the circumstances for detection and destruction of the cancer cells in the preliminary stage itself.

Seeing the best possible medical application in cancer treatment, of gold nanoparticles of different shapes and sizes produced using microwave exposed guava leaf extract and macerated aqueous extracellular dried clove buds (*S. aromaticum*) solution are found to be more beneficial. Because of the extraordinary features of gold nanoparticles like monodispersivity and adjustable core size, they play very important role for gene and drug delivery systems as promising scaffolds. These metal nanoparticles have wide scope in detection and destruction of cancer cells. With the knowledge of the procedures for synthesizing these noble metal nanoparticles and the development of new therapeutics, it may open new vistas in interaction of nanomaterials with biological systems.

The patented investigation involves the new method of synthesis of gold nanoparticle using bio-excretory like cow urine and characterization of these particles using various advanced analytical techniques. It is a new and cost- effective tool for clinical diagnosis in detection of cancer cell and will have a promising procedure for the future. Our strong belief is that the so obtained nano-functionalized particles can be scaled up industrially in a much easier way.

6.3 Nanotoxicology studies

The nanotoxicology study aimed to characterize the potential toxic effects of silver and gold nanoparticles in Sprague Dawley rats. They were subjected to detailed clinical, histopathological, hematological, biochemical, examination study during the exposure and at termination. Histopathological evaluation was performed even on liver, kidney stomach, spleen and heart in all animals groups under test. There was no prevalence of treatment connected mortality in rats exposed to AgNP and AuNP from 10μg/ kg and 500 μg/ kg. In conclusion we can say that when silver nanoparticles and gold nanoparticles are administered in the form of intravenous injections to Sprague Dawley rats daily for four weeks, the no_obseved_effect_level (NOEL) was found to be greater than 500 μg/ kg.