Chapter 6
Conclusion and future direction

6.1 Conclusion:

In this work, linoleic acid capped silver, gold and copper nanoparticles have been synthesized by chemical reduction method. Silver nanoparticles dispersed in chloroform show reddish brown colour. Gold nanoparticles dispersed in chloroform show reddish colour and copper nanoparticles dispersed in chloroform show light greenish colour. Size and shape of the nanoparticles have been analyzed by XRD and TEM study. XRD and TEM analysis show that silver nanoparticles are spherical in shape, having an average size of 12 nm. Similar studies show that gold nanoparticles are spherical in shape with an average size of 10 nm and average size of spherical copper nanoparticles is 5 nm. FTIR study indicates the capping of silver, gold and copper nanoparticles by linoleic acid. UV-Vis study shows that surface plasmon resonance peak for silver and gold nanoparticles lies in the visible range. Absorption peak for silver, gold and copper nanoparticles are observed at 422 nm, 510 nm and 241 nm respectively. Fluorescence of these nanoparticles has been observed, which can be attributed to the radiative recombination of electron hole pair between this d-valence band and sp-conduction band. Emission peaks are observed at 490 nm, 770 nm for silver and gold nanoparticles respectively. Copper nanoparticles of size 5 nm show two emission peaks at 450 nm and 625 nm corresponding to the high energy band and low energy band respectively.

In one application, the prepared nano particles have been tested for nano light emitting device (LED) by exploring the electroluminescence properties. Electroluminescence study of these nanoparticles shows that these nanoparticles are applicable as nano light emitting devices. This study reveal that silver, gold and copper can emit as nano LED with emission peak at 480 nm, 780 nm and 550 nm respectively.

Finally, these nanoparticles have been tested for antibacterial activity against some microorganism. Silver, copper and gold nanoparticles laden disk show good inhibition zone against a few bacterial strains.
6.2. Future research direction

Rich dividend is expected if in future, further research is carried out on noble metal nanoparticles in the following directions.

6.2.1 Modification in the synthesis process.

In the present work, it has been attempted to synthesize, characterize and test some applications of some noble nanoparticles. Based on the investigation, the present work can be continued further in the following directions:

6.2.1.1. Synthesis of noble metal nanoparticles with other capping agent.

In our present investigation, the stability of the nanoparticles has been observed up to 3 months or so. But the stability can be increased by providing some kind of strong coating around the nanoparticles, which can be an important direction of future work. Some of these coatings are amines, thiols, derivatives and different organic compounds. This stabilizing agent may be used to obtain noble metal nanoparticles with very narrow size distribution.

6.2.1.2. Synthesis of noble metal nanoparticles with other reduction agent

Synthesis of noble metal nanoparticles can be obtained with other suitable reduction agent, which may produce nanoparticles with very narrow size distribution, having greater stability.

6.2.1.3. Synthesis of other noble metal nanoparticles

Along with our prepared samples, some more nanoparticles may such as platinum, palladium may be tried for preparation.

6.2.1.4 Synthesis of rod shaped noble metal nanoparticles

Synthesis of rod shaped noble metal nanoparticles may be obtained by varying the temperature and $p^H$ value of the solution. By other reduction method also, rod shaped noble metal nanoparticles may be obtained. Rod like metal nanoparticles show better optoelectronic properties.
Further, core shell structure of noble metal nanoparticles can also be obtained using different reduction method.

6.3 Effect of swift heavy ions (SHI) irradiation on noble metal nanoparticles.

Effect of swift heavy ions (SHI) irradiation on noble metal nanoparticles may be examined using different characterization which may be an important direction of future research.

6.4 Applications

6.4.1. Noble metal nanoparticles as sensors:

To extend the present work, a new application of noble metal nanoparticles for sensing various substances may be tried. Surface plasmon resonance (SPR) of noble metal nanoparticles depends on the surrounding environment (e.g., Glucose). When nanoparticles be in contact with different environment, this SPR may shift its position. By studying this shift, presence of different substance can be sensed such as, glucose blood sugar.

6.4.2. Detection of cancer cell and its treatment:

Scattering amplitude of single molecule increases by many magnitude in presence of noble metal like gold and silver. This phenomenon is called surface enhanced Raman scattering (SERS). By surface enhanced Raman spectroscopy, cancer cell detection may be tried.

6.4.3. Antibacterial test of noble metal nanoparticles:

In continuation of this work, antibacterial activity of these noble metal nanoparticles can be tested with different bacteria other than Escherichia coli, Staphylococcus Basillus, Staphylloccoccus Aureus, and Pseudimonas Aureginosa.