CHAPTER 2

REVIEW OF LITERATURE

2.1 EXPERIMENTAL PROCEDURES AND METHODS INVOLVED IN THE SYNTHESIS OF SILVER NANOPARTICLES USING PLANT EXTRACT

10 g of Nelumbo lucifera leaves were boiled in 100 ml of distilled water contained in the conical flask. The resulting filtrate (12 ml) was taken and treated with 88 ml of aqueous 1 mM AgNO3 solution and incubated in dark condition, at room temperature. Appearance of brownish yellow coloured solution indicates the formation of AgNPs (Thirunavukkarasu et al 2011). 5 ml of seed extract was added to 20 ml of 10⁻³M aqueous silver nitrate solution, the mixture was heated at 80 °C and after 15 min of heating, the resulting solution become reddish in colour indicating the formation of silver nanoparticles (Harekrishna et al 2009). 5 mL, 10 ml and 15 ml of the leaf extract was added to 25 mL of the aqueous solution of AgNO3 (10⁻³ M) and stirred vigorously for 5 min. Reduction takes place slowly at 300 K and get completed in 30 min by stable light brown colour formation, depending on the intensity of colour formation, respectively to the volume of the extract added. Besides, at 373 K, silver nanoparticle was obtained by adding 25 mL of the extract to 100 mL AgNO3 (10⁻³ M). Also, by adding 5 mL of the extract to 25 mL of AgNO3 solution, the silver nanoparticles were synthesized by rapid reduction at 300 K at a pH value of 8, which was found to be intense brown in colour (Daizy Philip 2010).
O. tenuiflorum, S. tricobatum, S. cumini, C. asiatica leaves each of 1.5 g and peels of C. sinensis were boiled in 100 mL of de-ionized water. 2.5 ml of ammonium solution was added to 5 ml of 1 mM AgNO₃ solution, followed by the addition of plants extract from 1ml – 10 ml consecutively. The dark brown indicates the presence of silver nanoparticle formation (Peter et al 2012). By dissolving 10 g of dried powder in 100 mL of distilled water contained in the 500 mL of Erlenmeyer flask and then boiling for 10 minutes produces the plant extract. By mixing 10 mL of the plant extract with 90 mL of mM aqueous AgNO₃, the reduction of Ag ions takes place which was observed by a color change (Mukunthan et al 2011). 50 7mL of 10⁻³ M AgNO₃ aqueous solution was added to the leaf extract (1mL) and was kept at room temperature for 10 minutes. Under continuous stirring conditions, the yellow colour of the silver nitrate solution gradually changes to brownish yellow, which indicates the formation of silver nanoparticles (Govindaraju et al 2010).

Weighed biomass was added to 50 ml of 1 mM aqueous AgNO₃ solution placed in the 100 ml conical flask in the dark at room temperature for the synthesis of silver nanoparticles using Methanolic Extract of Eucalyptus hybrida leaves (Manis et al 2009). 5 ml of mangosteen leaf extract was added into 95 ml of aqueous solution of 1 mM silver nitrate. The leaf extract (1.5 ml) was added to 30 ml of 10⁻³ M AgNO₃ aqueous solution. It is then heated on water bath at 75 °C for 60 min. The color change from colorless to brown indicates the reduction of silver nitrate to silver ions (Ravichandran et al 2010). For the reduction of Ag⁺ ions, by taking two test tubes, 1mL of leaf broth was added to 9 mL of 1mM aqueous AgNO₃ solution in the first test tube. In the second test tube no leaf broth was added which serve as control. The test tubes were kept for 24 hrs of incubation at room temperature. After incubation, the so formed silver nanoparticle solution was subjected to
repeated centrifugation at 15,000 rpm for 20 min. The pellet so obtained was redispersed in the deionized water (Thirumurugan et al 2011).

12 ml of the aqueous extract of *A. indica* was added to 88 ml of 1 mM (10⁻³ M) solution of silver nitrate. The reaction was performed in dark at room temperature (Krishnaraj et al 2011). Aqueous solution of 10⁻³ M and 10⁻⁴ M silver nitrate (AgNO₃) and 10⁻² M concentration of D-sorbitol were prepared. 3 mL of the Polyalthia longifolia leaves extract and 1 mL of D-sorbitol were added to 40 mL of AgNO₃ solution and incubated at room temperature at 25°C and 60°C respectively. Dark brown colour formation indicates the appearance of silver nanoparticles.

Fine powder of *Boswellia ovalifoliolata* stem bark was added to 1 mM silver nitrate solution and centrifuged at 18,000 rpm for 25 min. The collected pellet was stored at -40°C. The supernatant was heated at 500°C to 950°C. During the heating process, a change in the color of solution was observed (Ankanna et al 2011).

### 2.2 METHODS ESTABLISHED FOR THE SYNTHESIS OF GOLD NANOPARTICLE

The synthesis of gold nano particles from various green sources are as follows. For the synthesis of the gold nano particles from the ginger rhizome broth, 5 ml of the ginger rhizome broth was added to 50 ml of 1Mm AgNO₃ solution at room temperature and it was shaken at 120 rpm in dark at 37°C (Chandransinha et al 2011). Gold nano particles were synthesised by *Dioscorea bulbifera* tubers (DBTE) by adding 5 ml of the green source to 95 ml of 1Mm aqueous HAuCl₄ solution where the pH is maintained as neutral and they were shaken at 150 rpm in dark at the temperature of 40°C.
Different volumes of clove extract (5-50 ml) were added to 4 Mm aqueous solution of auric chloride. The solution was stirred at 200 rpm (Ashwani Kumar Singh et al. 2010). Coriander leaf extract (0.5 ml) was added to 10 ml of 10^{-3} M HAuCl_{4} aqueous solution and kept at 30 °C (S. Venugopal Rao et al., K. Badri Narayanan et al. 2008). The leaf extract of Coleus amboinicus Lour (2 ml) was added to 10 ml of 10^{-3} M HAuCl_{4} aqueous solution and kept in the dark at 30 °C (Kannan Badri Narayanan et al. 2010). Hibiscus extract of 5 ml is added to a 30 mL solution of vigorously stirred HAuCl_{4}·3H_{2}O (5×10^{-4} M) and stirring continued for 1 min. The reduction is slow and completed in 1.5 hr. 5 ml of pine apple extract was added to 10^{-3} M aqueous HAuCl_{4} solution. It was allowed to settle at room temperature (Santosh et al. 2011). For the synthesis of gold nanoparticles from Allium Cepa 0.2 ml of Allium cepa broth was added to 50 ml of 10^{-3} M aqueous HAuCl_{4} solution (Umesh Kumar Parida et al. 2011). 60 mg of the finely coarse powder of Cassia fistula was added to 12 ml of double distilled water and it was stirred continuously and subsequently 50 ml of 1 Mm aqueous auric chloride solution and the stirring was continued (Daisy & Saipriya 2012). For the synthesis of gold nanoparticles a freshly prepared leaf extract of Dalbergia sissoo (5 ml) was added drop wise using a syringe to 50 ml 10^{-3} M HAuCl_{4} solution (Chandan Singh et al. 2012). 5 mL of Gnidiaglauca flower extract was added to 95 mL of 10^{-3} M aqueous chloroaauric acid solution. The pH of the extract was found to be neutral and the flasks were shaken at a speed of 150 rpm in the dark at 40°C (Sougata Ghosh et al. 2012). To a 60 mL of 1 × 10^{-3} M aqueous solution of auric acid 2 mL of Chenopodium album leaf extract was added at room temperature for 15 min (Amarendra Dhar et al 2010).
2.3 UV SPECTROMETRY ANALYSIS OF SILVER NANOPARTICLE SYNTHESIZED USING DIFFERENT PLANT EXTRACTS

The Extracellular synthesis of silver nanoparticles using leaves of *Euphorbia hirta* involves the reduction of pure Ag+ ions was measured by the UV-Vis spectrum of the reaction medium at 5 hours by using UV-VIS spectrophotometer UV-2450 (Shimadzu). Colloidal silver nanoparticles from *Hevea brasiliensis* has the characteristic surface plasmonic absorption band around 435 nm and is given by UV–Vis spectra. Decreased particle size is due to lower AgNO₃ concentration. The silver nanoparticles are spherical shape with diameters ranging from 2 nm to 100 nm. UV–vis absorption spectra of the colloidal dispersions were recorded using the Ultrospec 2100 spectrophotometer. The distribution of the particle size was measured by Zeta-Sizer system (Malvern Instruments). The biosynthesized silver nanoparticles from Mangosteen leaf has a resolution of 1 nm between 300 and 700 nm and possess a scanning speed of 300 nm/min was determined by UV–visible absorption spectrophotometer and the maximum absorbance was found to be at 438 nm. Synthesis of silver nanoparticles from plant extract shows a maximum absorbance occurs at 430 nm, which increases as a function of reaction time. While using Magnolia leaf broth, the final absorption intensities at 430 nm will be get increased upto 1.5 Angstrom unit, when compared with the Neem leaf broth, whose intensity only get increased upto 0.5 Angstrom unit (Song et al 2009). There is no evidence of absorbance for the UV-vis spectra range between 400 nm – 800 nm for the pure solanum torvum plant extract, but when the plant extract gets exposed to AgNO₃ solutions, maximum absorbance was found at 434 nm, due to the formation of nanoparticles.
The bioreduction of Ag+ ions using Eucalyptus hybrid extract was carried out by sampling of aliquots (0.2 ml) of the suspension, then diluting the samples with 2 ml of deionized water and measuring the UV–Vis spectra of the resulting diluents. The resulting UV–vis spectroscopy analysis was carried out at room temperature on ELICO UV spectrophotometers at a resolution of 1 nm. It is observed that the resonance band occurs at 412 nm steadily increases without any shift in the peak wavelength. Formation of stable silver nanoparticles using the seed extract of Jatropha curcas in aqueous colloidal solution are confirmed using UV–vis spectral analysis. Characteristic surface plasmon absorption bands are observed at 425 nm for silver nanoparticles synthesized from $10^{-3}$ (M) AgNO$_3$, for the fixed volume fraction ($f = 0.2$) of aqueous seed extract. By increasing the concentration of silver nitrate solution, Surface Plasmon Resonance band shifted to the red was observed from $10^{-3}$ to $10^{-2}$ (M) concentration and the colour changes from reddish yellow to deep red.

2.4 UV-VISIBLE SPECTROSCOPY (UV-VIS) ANALYSIS FOR THE CONFIRMATION OF GOLD NANOPARTICLE FORMATION

UV–Vis spectroscopy measurements of gold nanoparticles prepared by sodium citrate reduction method were performed using a Specord 205 with a 1-cm optical length cuvette with a spectral resolution of 1 nm at room temperature. The gold nanoparticles formed are observed by a change in color since small nanoparticles of gold are ruby red. The nanoparticles are kept separated due to a layer of absorbed citrate anions on the surface of the nanoparticles. The presence of this colloidal suspension can be detected by the UV-Vis spectroscopy. The reduction process was fairly slow in the process. The absorption band obtained at 530 nm is the characteristic SPB of gold nanoparticles. But, there was very small shifting and broadening of SPB
(Surface Plasmon Band), which revealed the formation of gold nanoparticles with nearly constant size distribution. Using UV-Vis spectroscopy, the kinetics of the adsorption process was investigated in order to find a suitable time interval of self-assembling. The absorbance shown at 530 nm which rose from the plasma resonance of the colloidal gold nanoparticles increased gradually with the deposition time. It was found that maximum adsorption of colloidal gold nanoparticles were obtained after 150 min. However, increase in size on long time reaction is probably due to the initially formed particle which serves as a nucleation site and these results in layer by deposition of gold which resulted in the increase in size. Also the deposition was fairly slow as chemical reduction being a slow process. This result is quite similar to the seed mediated growth of gold nanostructures (Agnieszka Sobczak et al 2011).

The UV-Vis absorption spectrum of the colloidal gold nanoparticles prepared from HAuCl₄·3H₂O (Acros, 99.8%), tetra-n-octylammonium bromide (Acros, 98%), NaBH₄ (Acros, 99%), 1-nonanethiol (C₉H₁₉SH) (Aldrich, 99%) reagents was measured using a Shimadzu UV-1601PC double beam spectrophotometer in the range of 200 to 800 nm with 2 nm resolution. For the UV-vis experiment, 1 mg sample was first dissolved in cyclohexane, and then adjusted to a suitable concentration for the measurement. From the typical UV-Vis spectrum of the system, it can be seen that a clear peak, which corresponds to the plasmon excitation, was obtained at around 518 nm. In addition, a continuous rising background of shorter wavelength can also be observed, which might result from the Mie scattering of the nanoparticle suspension (Jiang Peng et al 2001).

The potential dependent UV-visible spectral changes of gold nanoparticles immobilized on organic monolayers coated over an ITO electrode and dynamic behaviors of surface-modified nanoparticles at a
Au(111) electrode were measured using the results of electrochemical and spectro electrochemical measurements. The UV-vis transmission-absorption spectra were measured for a 4-aminobutyl siloxane coated ITO electrode on which citrate-stabilized Au nanoparticles of an 11-nm diameter were immobilized. Due to charging and discharging of the particles the nanoparticles showed a potential dependent shift of the plasmon absorption band. At more negative potentials, a sharper and greater absorption peak was observed at a shorter wavelength. This assignment of charging and discharging process were supported quantitatively by the Mie-Drude model proposed by Unget al. A combined use of potential step chronocoulometry enables us to estimate the charging amount as being ca.1500 electrons/V of a particle. Potential-modulated UV-vis transmission-absorption (PMTA) spectroscopy was used to track the spectral change. The frequency dependence of the PMTA signal at $f > 8$ Hz is in line with the Ac charging current. However, when the time scale of the measurement was set for a longer period, a slow decay of the absorbance was observed. The change in absorbance with time after potential step perturbation was a sum of rapid change within 1 s and with a half life ranging from 30 to 150 s for an exponential decay. The slow decay depends on the wavelength, which indicates that the spectral curve is independent of time. In a buffer solution of 1.0 M NaClO$_4$ with a PH value of 7, the slow decay component was negligibly small, whereas in 1.0 M NaCl solution, the response totally consisted of the slow decay. The decay curve was not affected by the increase in citrate concentration in the electrolytic solution. These results indicate that the slow spectral change originate from a very slow surface processes under the influence of anionic adsorption (Takamasa Sagara et al).
Gold nanoparticles with nominal sizes of 10, 20 and 50 nm were (Products MKN-Au-010; MKN-Au-020; MKN-Au-050, MK ImpexCorp, Canada) were subjected to UV–visible characterization at concentrations from \(0.2 \times 10^{-3}\) to \(1 \times 10^{-2}\)% using a UV-Visible spectrophotometer (UV-1601 PC, Shimadzu, Japan; H14 grating (UV through shortwave NIR with an optical resolution of about 0.4nm)). The absorbance measurements were observed over the wavelength range of 250-700 nm using 1 cm path length quartz cuvettes, which was cleaned before use by sonicating them in deionized Water for 5 min and then rinsing again with deionized water. All solutions remained at a pH value of 6.3. The maximum in the gold absorbance intensity obtained around 517nm. The surface plasmon excitation of small spherical gold nanoparticles is attributed to the intense absorption peak observed at 517 nm. When the Au nanoparticle size is changed from 10 nm to 50 nm, the maximum extinction of Surface Plasmon Band (SPB) is shifted from 517 nm to 532 nm in the visible region which may be generally attributed to the surface plasmon oscillation of free electrons. The surface Plasmon resonance of the gold particles is red with increase in particle size in accordance with Mie theory. At a constant nanoparticle size, the absorbance were found to be proportional to the concentration of gold. Since the increased number of nanoparticles provides increase in surface for surface plasmon resonance. The optical properties of gold are due to 5d (valence) and 6sp (conduction) electrons. The outermost d and s electrons of the constituent atoms should be treated together which leads to six bands, out of six, five of them are fairly flat, lying a few electron volt below the Fermi level, and are usually denoted as d bands and the sixth one, is almost free-electron which is known as the conduction band or sp band. Gold luminescence from single photon has been described in a three-step process, first excitation of electrons from the occupied d to the sp band which is above the Fermi level for generating
electron–hole pairs. Second, scattering of electrons and holes on the picosecond time scale with partial energy transfer to the phonon lattice and third, is the recombination of an electron from an occupied sp band with the hole resulting in photon emission (Mohamed Anwar K Abdulhalim et al 2012).

The UV-visible spectrum of the Au-Ti-MPS showed the absorption band near at 220 nm, which originated from the charge transfer of oxygen 2p electron to the empty 3d orbital of Ti4+, which indicates that framework of Ti which exists in tetrahedral coordination. The absorption band was observed at 520 nm which was due to the absorption of surface plasmon vibration in gold particles. Using UV-visible spectra the band gap energy is calculated to be 2.38eV. With an increase in concentration of Cu2+ and Zn2+ ions the width of the Plasmon resonance peak progressively increases. The absorbance of light of 600 nm wavelength varies with increase in concentration of both the analytes. The effect of capping the nanoparticles with Ti-MPS provides a linear response with the increase in concentration of analytes. According to the research paper on Chitosan-capped gold nanoparticles, showed that the spectral shape of every sample is clearly distinguishable due to the effect of exposure to varying concentration of Cu2+ ions on their optical absorption spectra. The variation is however not as uniform for Zn2+ ions. Thus, with the comparison of changes in absorption value at 650 nm due to varying Cu2+ ions approximately gave a linear response to chitosan-capped gold nanoparticles (Tay Shiau Fong et al 2012).
2.5 FOURIER TRANSFORM INFRA RED SPECTROSCOPY ANALYSIS FOR THE CHARACTERIZATION OF SILVER NANOPARTICLE FORMATION

The selected area electron diffraction (SAED) patterns from *Hevea brasiliensis* shows that the silver nanoparticles have face ammonia facilitate reduction of the silver ions showed by FTIR. The data has angle of (90°) and f wavelength of (633 nm He–Ne laser). By dropping the solutions onto a silicon plate with Bomem MB 100 spectrometer obtains a film Fourier-transform infrared spectra (FTIR) in the region between 4000 and 400 cm\(^{-1}\). The purified suspension from Mangosteen leaf was freeze dried to obtain dry powder and hence the dried nanoparticles were analyzed by FTIR-JASCO 4100 spectrophotometer.

The FTIR spectrum of the *S. torvum* leaf extract shows peaks at at 1648, 1535, 1450 and 1019 cm\(^{-1}\). The peak at 1450 cm\(^{-1}\)(-COO) of carboxylate ions is responsible for stabilizing the silver nanoparticles. Selected area electron diffraction (SAED) pattern using seed extract of *Jatropha curcas* suggests the polycrystalline nature of the present synthesized silver nanoparticles. It is observed that the silver nanoparticles solution is extremely stable for nearly 65 days with only a little aggregation of particles in solution. FTIR spectroscopy measurements show the presence of three bands 1744, 1650, 1550 and 1454 cm\(^{-1}\). The strong absorption at 1744 cm\(^{-1}\) is due carbonyl stretching vibration of the acid groups present in the extract. The bands at 1650 and 1550 cm\(^{-1}\) are characteristic of amide I and II bands respectively. The amide band I is due to the stretch mode of the (-CO) carbonyl group coupled to the (-NH) amide linkage while the amide II band is due to the N–H stretching modes of vibration in the amide linkage.
FTIR absorption spectra of *Dioscorea bulbifera* tuber extract shows a strong peak at 3300 cm\(^{-1}\) representing O–H bond. But after bioreduction it is not seen in the extracts of *D. bulbifera*. The absorbance bands at 2931 cm\(^{-1}\), 1625 cm\(^{-1}\), 1404 cm\(^{-1}\), and 1143 cm\(^{-1}\) are associated with respect to the stretch vibrations of alkyl C–C, conjugated C–C with a benzene ring, bending of C–O–H and C–O stretch in saturated tertiary or secondary highly symmetric alcohol in *D. bulbifera*. The presence of peaks at 3749 cm\(^{-1}\) and 1523 cm\(^{-1}\) indicate the –NH\(_2\) symmetric stretching and N–O bonds in nitro compounds (Sougata et al 2012).

The AgNPs was synthesized using *A. spicifera* Shows Intense FTIR bands were observed at 3351.28 cm\(^{-1}\), 2633.71 cm\(^{-1}\), 2083.50 cm\(^{-1}\), 1637.18 cm\(^{-1}\), 1082.87 cm\(^{-1}\) and 712.34 cm\(^{-1}\). The major FTIR bands were absorbed at 3351.20 cm\(^{-1}\), 2633.74 cm\(^{-1}\) and 712.34 cm\(^{-1}\). They indicates the presence of alcohols and phenols (O–H), carboxylic acids and its derivatives (C=O) and Chloroalkanes (CX) respectively(Kumar et al 2012).

FTIR measurements for *Gliricidia sepium* shows the absorption peak at around 1020 cm\(^{-1}\) can be assigned as absorption peaks of -C=O- C- or – C-O-. The absorption spectra at 1638 cm\(^{-1}\) result from stretching of vibration of -C=C-. The peak at around 1640 cm\(^{-1}\) indicates the amide I bonds of proteins. The bonds or functional groups such as -C=O- C- and -C=O- are derived from heterocyclic compounds. The amides I bond derived from the proteins are the capping ligands of the nanoparticles (Raut et al 2009).
2.6 FOURIER TRANSFORM INFRARED SPECTROSCOPY (FTIR) ANALYSIS FOR THE IDENTIFICATION OF THE BONDS/LINKAGES, STRETCHES STABILIZING THE GOLD NANOPARTICLE FORMATION

The FTIR spectrum recorded from the chloroauric acid solution after reaction with *Mucunapruriens* plant extract revealed the strong bands observed at 1627, 1384 and 1047 cm\(^{-1}\). The band formed at 1627 cm\(^{-1}\) corresponded to C=O stretching vibrations. The band at 1384 cm\(^{-1}\) corresponds to C=C stretching of aromatic amine group and 1047 cm\(^{-1}\) is characteristic of C-N. The weaker band at 1047 cm\(^{-1}\) was raised due to carbonyl stretch in proteins. These bands may be assigned to the I and II amide bands of proteins, respectively. It is well known that proteins can bind to gold nanoparticles either through free amine groups or cysteine residues in the proteins and thus, stabilization of the gold nanoparticles by surface-bound proteins is possible. It is believed that one or more of these proteins may be enzymes which reduce chloroaurate ions and cap the gold nanoparticles formed by the reduction method. It is also possible that different types of proteins affect the capping and stabilization of the gold nanoparticles. A green chemistry approach based biosynthesis of gold nanoparticles by *Mucuna* seed extract is performed (Subramanian Arulkumar et al 2010). The infrared spectra of nifedipine nanoparticles were recorded in the mid-infrared region (MIR) within the range of 400 to 4500 cm\(^{-1}\). IR absorption spectrum of the functional groups varied over a wide range due to the complex interaction of atoms within the molecule. It was found that many functional groups gave characteristic IR absorption at specific narrow frequency range. A functional group often gives rise to several characteristic absorptions range though multiple functional groups may absorb at one particular frequency. The FTIR band obtained at 3415 cm\(^{-1}\) represent O-H group stretching of O-H, H-bonded single bridge. 3021 cm\(^{-1}\) is a region due to stretching vibrations of Ar-H,
(-CH) several band at 2911 cm\(^{-1}\) (C-H), 2 or 3 band of methyl group. The aryl carboxylic group present in the region 1603 cm\(^{-1}\) represents C=O stretching vibration. 1617 cm\(^{-1}\) represents the presence of pyridine nucleus ring breathing. The aryl nitro group is also present in the region of 1534 - 1467 cm\(^{-1}\). Etherial group is present at 1115 cm\(^{-1}\), which represents the strong stretching of C-O-C (Parida et al).

Fourier transform infrared (FTIR) spectroscopy for Fe\(_3\)O\(_4\)-gold nanoparticles was carried out by a Bruker FTIR-6000 (Bruker, Germany) using KBr discs to study the interaction of functional groups in chitosan with the nanoparticles surface. The FTIR spectra of chitosan, formaldehyde cross linked with chitosan hydrogel and Fe\(_3\)O\(_4\) Chitosan hydrogel shown a broad band at 3429 cm\(^{-1}\) due to the overlapping of -OH and -NH groups in chitosan. The band found at 2902 cm\(^{-1}\) corresponds to C-H bonds. The band found approximately at 1656 cm\(^{-1}\) is due to amide band C-O stretching, along with N-H deformation, and band at 1592 cm\(^{-1}\), is due to the characteristic peak of the NH\(_2\) group. The absorption peaks at 1412 cm\(^{-1}\) is characteristic of -CH\(_2\)- and, skeletal vibration involving C-O-C Bridge stretching of the glucosamine residue, which is responsible for the band at 1107 cm\(^{-1}\). The 1025 cm\(^{-1}\) band is related to CH-OH bonds in cyclic compounds. The peaks at 587 and 477 cm\(^{-1}\), indicates the stretching, and the variation modes of Fe-O which confirms the presence of crystalline Fe\(_3\)O\(_4\). FTIR spectrum of dispersed Fe\(_3\)O\(_4\) nanoparticles in the chitosan hydrogel, confirmed the considerable changes of the immobilized Fe\(_3\)O\(_4\) nanoparticles based on the shape and frequencies of the bands, which indicates the interaction of functional groups in chitosan with the Fe\(_3\)O\(_4\) at the surface (Hossein Salehizadeh et al 2012).

FTIR measurements carried out on neat gold nanoparticles capped with glutathione and lipoic acid prepared by borohydride reduction showed number of peaks present in the freemolecules after coupling to the gold
nanoparticles (peaks at 549 cm$^{-1}$, probably due to S-S stretch, and 2,525 cm$^{-1}$ due to S-H stretch, 671 cm$^{-1}$ and 518 cm$^{-1}$, probably due to S-S stretch) practically disappears. Characteristic frequencies for the peptide bond were not significantly affected. The vibrations are quenched or shielded by the gold nanoparticles and the energy is transferred to the internal modes of the nanoparticles. One of the reasons is that the molecules attached to the nanoparticles on the side of IR source get absorbed and the vibrational energy is not transmitted to the detector, and the molecules on the other side of the nanoparticles get transmitted but vibrational energy is not sufficient to be detected. The S-S stretch vibration in glutathione and S-H stretch vibration in lipoic acid disappears completely after coupling. A few vibrational modes that still survive can be seen in the IR spectrum of the coupled gold nanoparticles (Gautham Kumar Ahirwal & Chanchal Mitra 2009).

### 2.7 X Ray Diffraction Analysis for the Determination of the Size of the Silver Nanoparticle

Biologically synthesized silver nanoparticles from Eucalyptus hybrida shows X-ray diffraction (XRD) analysis. It is obtained using an X$^\text{*}$Pert Pro X-ray diffractometer operated at a voltage of 40 kV and 30 mA current with Cu K$_\alpha$ radiation. Silver nanoparticles synthesised from aqueous leaves extract of *A. indica* were coated on XRD grid and is used for XRD studies. The spectra were analysed by using Philips PW 1830 X-ray generator. It operates at 30 mA current and 40 kV voltage with Cu K$_\alpha$ radiation. XRD analysis shows three distinct diffraction peaks of 38.1$^\circ$, 44.3$^\circ$ and 64.4$^\circ$ at 2$\theta$ values indexed to (1 1 1), (2 0 0) and (2 2 0) the crystalline planes of the face centered cubic structure of metallic silver. In the bioreduction process, the average grain size of the AgNPs formed is estimated to be 24 nm.
The XRD patterns of silver nanoparticles synthesized from seed extract of *Jatropha curcas* has a number of Bragg reflections with 2θ values of 38.03°, 46.18°, 63.43° and 77.18° corresponding sets of lattice planes to the (1 1 1), (2 0 0), (2 2 0) and (3 1 1) were observed. They are indexed as the band for face centered cubic structures of silver. The XRD pattern shows that the formed silver nanoparticles are crystalline in nature. The X-ray diffraction patterns for *S. torvum* leaf extract show the presence of intense peaks of silver nanoparticles whose average size was calculated as 14 nm.

Dried silver nanoparticles from *Nelumbo nucifera* leaf extract were coated on XRD grid. The corresponding spectra were recorded by using Phillips PW 1830 instrument which operates at a voltage of 40 kV and a current of 30 mA with CuKα1 radiation. The average size of the silver nanoparticles was calculated as 45 nm. The XRD patterns for silver nanoparticles synthesized using Neem leaf broth has a number of Bragg reflections which corresponds to the (111), (200), (220), (311), and (222) sets of lattice planes. Thus it clearly shows that the silver nanoparticles are formed by the reduction of Ag⁺ ions, which are crystalline in nature (Shiv Shankar et al 2004).

Formation of silver nanoparticles from papaya fruit extract shows three intense peaks which ranges from 10° to 80°. The Average size of the particles was measured as 15 nm (Devendra et al 2009). The XRD patterns of *Ag/Vitex negundo* indicate the face-centered cubic (fcc) structure of silver nanoparticles (Amal et al 2011). The silver nanoparticles showed XRD peaks at 38.17°, 44.31°, 64.44°, 77.34° and 81.33° corresponding to the face-centered cubic (fcc) planes (111, 200, 220, 311 and 222) of the silver crystals, respectively (Mohzen et al 2011).
The X-ray diffraction (XRD) pattern for plant-mediated synthesis of silver nanoparticles has photons of energies, in the range of 100 eV–100 keV. A short-wavelength X-rays (hard X-rays) which ranges in between 1–120 keV were used for diffraction applications (Vineet K et al 2009). The X-ray diffraction (XRD) pattern of dry silver nanoparticle using Chenopodium album leaf extract exhibit diffraction peaks at 38.13°, 44.21°, 64.47°, 77.37°, 81.47°, 98.01°, 110.56° and 114.80°.

2.8 XRAY DIFFRACTION (XRD) ANALYSIS FOR THE PREDICTION OF THE SIZE AND PHASE OF THE GOLD IN NANODIMENSION

The crystal structure of ZnO and Au/ZnO were studied using an X-ray diffraction (XRD) diffractometer (X’Pert Pro X-ray diffraction system, analytical). Using sample holder the sample were ground and pressed to get a smooth plane surface, and the diffraction pattern were recorded over a 2θ range of 30°-120°. The diffractogram obtained was compared with the standard database of the International Centre for Diffraction Data (ICDD) (HananiYazid et al 2010). XRD measurements of the gold nanoparticles synthesized from Allium cepa extract was done on a Phillips PW 1830 instrument operated at a voltage of 40 KV and 20 mA current with Cu K radiation which showed three characteristic peaks. The characteristic peaks which corresponds to (111), (200), (220) of Au are located at $2\theta = 38.29^\circ$, 44.43° and 64.68° (Umesh Kumar Parida et al 2011). The gold nanoparticles which protects dendron were prepared with a phase-transferred process by self-reduction method and was resulted to XRD measurement showing three strong Bragg reflections corresponding to (111), (200) and (220) reflections of face centered cubic structure of gold. Thus from the XRD result it was predicted that the Au particles formed in the solution are crystalline (Guohuo Jiang et al 2007).
The XRD measurements obtained from *Senna siamea* (Lam.) leaf extract showed three intense peaks, and the diffraction pattern were recorded over a whole spectrum of 2θ values ranging from 30 to 70. Diffraction pattern of thin thoroughly dried nanoparticle films on glass slides were recorded on an x-ray diffractometer with a Cu K+ (1.54 Å) source. The XRD measurement of the leaf extract showed three intense diffraction peaks which corresponded to (100), (120) and (220) reflections of face centered cubic structure of metallic (Rajasekhar Reddy et al. 2012). The XRD pattern of gold nanoparticles synthesized by diethyl ether phytochemical fraction showed clear peaks of cubic phases at 38.2 (1 1 1), 44.3 (2 0 0), 64.9 (2 2 0), 77.5 (3 1 1) and 81.5 (222), which confirmed the crystal nature of gold nanoparticles. Formation of small sized Au nanoparticles was indirectly represented by the broad bottom width of the peaks (Mohammad Feroze Fazaludeena et al. 2012).

### 2.9 SCANNING ELECTRONMICROSCOPY FOR STUDYING THE MORPHOLOGY AND SHAPE OF SILVER NANOPARTICLE

The formation of spherical shaped silver nanoparticle extracted through *Syzygium aromaticum*, whose size ranging in between 20 nm to 149 nm was confirmed by scanning electron microscopy. Scanning Electron Microscopic (SEM) analysis was established using Hitachi S-4500 SEM machine. Silver nanoparticle synthesized within 10 minutes has an absorbance at 430 nm and the broadening of the peak indicates indicates the polydispersion of the particle. The SEM shows that spherical shape nanoparticle formed with a diameter ranges from 40 nm to 50 nm.

The high density silver nanoparticles synthesized by the *A. paniculata* shows SEM image which was done by using SEM (JEOL-MODEL 6390). The average size was from 35-55 nm with inter-
particle distance and the shape were proved to be spherical. The aggregation of the nanoparticles indicates that they were in the direct contact, but were stabilized by a capping agent (Panneerselvam et al 2011). The silver nanoparticles synthesized by Novel Pseudomonas sp shows the sharpening of the peaks which indicates that the particles are in the nano regime. The average size of the silver nanoparticles from 20 nm – 100 nm. SEM observations were performed on an H-600 electron microscope which operates at an accelerating voltage of 120 kV. The shape of the silver nanoparticles was spherical and gets aggregated into larger irregular structure with no well-defined morphology (Muthukannan et al).

Green Synthesis of Silver Nanoparticles from Cleome Viscosa was analyzed by SEM. SEM observations were established by using ZEISS EVO 40 EP Electron microscope. SEM analysis shows that the silver nanoparticles are uniformly distributed on the surface of the cells. But it does not indicate that all the nanoparticles are bound to the surface of the cells. This may be the particles dispersed in the solution may also be deposited onto the surface of the cells (Bharathi et al 2012).

2.10 SCANNING ELECTRON MICROSCOPY (SEM) ANALYSIS OF THE GOLD NANOPARTICLE FOR STUDYING THE SURFACE MORPHOLOGY

Structural quality of the low temperature nanoparticles were studied in scanning electron microscopy (SEM) at a high resolution with FEG SEM microscope at low accelerating voltage. It indicated that most of the ZnO nanoparticles were in the form of nanorods of about 10 nm radius and 200 nm length. Larger crystallites of low concentration were also present. Other low temperature ZnO nanoparticles had a shape of small hexagons and were of nanometer size (Tomaszewska Grzeda et al 2005).
The SEM images of the colloidal Ag solutions prepared at 80° C confirmed the existence of very small and uniform spherical nanoparticles. Size of the particle and its distribution depends on the relative rates of nucleation and growth processes, and also with the extent of agglomeration. However it’s very difficult to control the rate and, the consequent size distribution. In this case the hydroxethyl cellulose polymer, possessing a high electrical charge density when coupled with a high viscosity, arrests the microscopic motions of the silver ions which in turn inhibits colloidal silver formation. As a result, mainly mono dispersed silver particles are present in the product (George Mulongo et al 2008).

Marine cyanobacterium, Oscillatoria willei in AgNO3 was studied in Scanning Electron Microscopy. It was found that at room temperature, the addition of AgNO3 to the cyanobacteria caused the precipitation of silver nanoparticles at cell surfaces. Small spherical silver nanoparticles of size ranging from 100 nm – 200 nm (extracellularly) were also precipitated in the solution and the silver nanoparticles were deposited at cell surfaces (Mubarak Ali et al 2011). The surface morphology of CdSe nanoparticles was studied by SEM technique which showed that the materials are polycrystalline in nature and particle sizes were found to be 3–4 microns. The particle size was greater than the crystallite size which was measured in TEM (Karupusamy Kandasamy et al 2009). Prepared colloids of Eu₂O₃ nanoparticles were characterized by scanning electron microscopy. It was found that the metal nanoparticles were spherical in shape of various diameters. The colloidal solutions contained nanoparticles with the size distribution of 50-100 nm in diameter (Katerina piksova et al 2011).

The SEM analysis of the silver nano particles synthesized from Cardiospermum helicacabum showed spherical shaped and well distributed particles without aggregation in the solution with the average size of about
5 nm to 50 nm. Synthesis of AgNO$_3$ was quite fast and Nanoparticles were formed within few hours due to the contact of AgNO$_3$ with the plant leaf sample filtrate. More nanoparticles are obtained by increasing the interaction time. Some time non spherical polyhedral particle were also found, and with the increase in the interaction time, the aggregation and anisotropy shape is also increased. It showed the formation of silver ions with a Skew spherical shape and they had the size range of 60 nm – 80 nm. It also showed the formation of Skew spheroid shaped silver ions with a size range of about 5-50 nm min (Bhaskar Mitra 2012).

### 2.11 HIGH RESOLUTION TRANSMISSION ELECTRON MICROSCOPY FOR SILVER NANOPARTICLES

Colloidal silver nanoparticles from *Hevea brasiliensis* were analysed using JEOL-JEM-100 CXII instrument, the morphology of the silver nanoparticles were studied by transmission electron microscopy (TEM), by drying a drop of the washed colloidal dispersion onto a copper grid covered with a conductive polymer. The size and shape of Ag nanoparticles synthesized using mangosteen leaf was visualized using 200 kV Ultra High Resolution TEM (JEOL-2010). TEM grids were prepared and the residual solution of 100 ml after reaction was centrifuged at 5000 rpm for 10 min. The resulting suspension was redispersed in sterile distilled water of 10 ml and centrifugation process was repeated for three times. Biologically synthesized silver nanoparticles on *Bacopa monnieri* uses 25 μl of sample and sputter it on a coated copper stub using HRTEM (JEOL-3010) for electron microscopic study. Dried nanoparticles were coated on XRD grid and the spectra were recorded by using Philips PW 1830 X-ray generator. It operated at a voltage of 40 kV and a current of 30 mA with Cu Kα1 radiation. Atomic absorption spectrophotometer (AAS) was used to assay Concentration of silver.
HRTEM analysis clearly shows that the size of the AgNPs ranges from 2 to 50 nm and also shows that they were well dispersed. The shape was almost spherical to cubic. By using Scherer’s formula \( t = \frac{0.9\lambda}{\beta \cos \theta} \), an average crystal size \( t \) of the silver nanoparticles can be estimated from the X-ray wavelength of the Cu K\( \alpha \) radiation \((\lambda=1.54\text{Å})\), the Bragg angle, and the width of the peak at half height in radians. The average size of the silver nanoparticles from *solanum torvum* is calculated as 14 nm. The result is comparable with TEM image of the reduction of AgNO\(_3\) by *S. torvum* extract. High Resolution Transmission Electron Microscopy (HRTEM) shows that the silver nanoparticles are spherical in structure. Using HR-TEM images, the average size of silver nanoparticles was obtained as 14 nm.

HRTEM analysis of biogenic Ag nanoparticles prepared by *Ulva lactuca* extract shows that the size measurement of the particle was found to 20 – 30 nm in diameter. Formation and stability of silver nanoparticles using seed extract of *Jatropha curcas* in aqueous colloidal solution shows that, by increasing concentration of silver nitrate SPR band shifted to the red from \( 10^{-3} \) to \( 10^{-2} \) (M) and the colour changes were observed from reddish yellow to deep red. HRTEM shows that the particles were spherical with diameter ranges from 15 to 25 nm. Larger and uneven shaped particles with diameter 30–50 nm. Sizes of the particle at two different AgNO\(_3\) concentrations are in agreement with the observed surface plasmon resonance (SPR) band at 425 and 452 nm respectively.

2.12 TRANSMISSION ELECTRON MICROSCOPY (TEM) ANALYSIS FOR THE DETERMINATION OF SIZE AND SHAPE OF THE GOLD NANOPARTICLE

TEM test of gold coated iron nanoparticles showed cores with a size of about 11 nm at the central part of the nanoparticles in the dark contrast. The shells with a thickness of about 2.5 nm were shown in the light contrast.
at the periphery of the particles. The average diameter of the core-shell particle is 16 nm with approximate size deviation of 15%. The composition of the nanoparticles was estimated by EDS (Electron Dispersive Spectrum) and was found to be in the ratio of 57.2 to 42.8, which correspond to the mole ratio of Fe: Au. EDS showed the presence of copper, gold, and iron where copper is from the TEM grid, and the gold and iron are from the sample. This indicates that the molar ratio between Fe and Au is 1.4: 1 (Zhihui Ban 2004). The TEM image of gold nanoparticles synthesized by citrate reduction method showed particles which appeared to be boot shaped and spherical in shape with an average size of about 20 nm and 500 nm approximately (Joshi & Nidhi 2010). The TEM images of the nanoparticles synthesized using Poly Vinyl Pyrollidone appeared to be pentagon, triangle and octagon shape with a size ranging from 20 nm to 200 nm. From the TEM study it is evident that via chemical synthesis, nanoparticles of different size and shape can be obtained (Sanda Boca et al 2011).

Gold nanoflower synthesized using chemical reactants L-ascorbic acid (L-AA), which acts as gold salt reducer and tetrachloroauric acid (HAuCl4), showed a TEM image which resembled like flowers consisting of a solid gold core of about 40 nm with many short irregular petals (protrusions) of about10 nm average size was investigated. The arrangement in long chains or clusters is a typical single spherical nanoparticles which result from particle drying on the TEM grid. It should be pointed out that the synthesized flower-shaped gold nanoparticles possess many characteristics that make them suitable for Surface Enhanced Raman Spectroscopy (SERS) substrates (Madu et al 2011). The gold nanoparticles synthesized from 1-alkyl, 3-methyl imidazolium based ionic liquids showed a TEM image at a temperature between 120°C and 180°C. At 120°C it showed particles having a broad size distribution, with a mean diameter of 20 nm, and rough spherical shapes. The TEM images of gold nanoparticles grown in (Emim) (MS)
showed particles with a mean diameter of ca. 5 nm, which appeared very small regardless of the reaction temperature. But, however, the aggregation of the particles changes with reaction temperature. At 120°C, relatively small particles aggregates with an overall diameter between ca. 20 and 50 nm, at 160°C and 180°C the aggregates become larger and reach over 200 nm at 180°C. At 160°C aggregates have a sponge-like appearance. At 180°C, they assume shapes that are reminiscent of crystalline organization than at 120°C, which showed the coexistence of individual particles and larger aggregates. The particles appear some what larger at 140°C and 160°C and TEM suggests that they are more strongly aggregated than at 120°C. At 180°C the individual particles are rather present as individual particles and their is small spacing between each particle.

2.13 ANTIMICROBIAL APPLICATIONS OF THE SILVER NANOPARTICLE SYNTHESIZED BY DIFFERENT METHODS

It is a well known fact, that silver ions and nanoparticles are highly toxic and hazardous to microorganisms. It is found out that the silver nanoparticles have many inhibitory and bactericidal effects and so its application is extended as an antibacterial agent. The antibacterial activity of silver nanoparticles is estimated by the zone of inhibition. Many different studies have shown that silver nanoparticles can affect the membrane permeability and respiratory function by attaching to cell surface. Another possibility is that silver nanoparticles not only interact with the surface of the membrane, but can also penetrate deep inside the bacteria. Another observation explains that the silver nanoparticles have relatively higher anti-bacterial activity against gram negative bacteria than gram positive bacteria, which may be due to the thinner peptidoglycan layer and presence of beta barrel proteins called porins.
Very recently, nanoparticles have gained significance in the field of Biomedicine. The most significant and distinguishing property of nanoparticles is that they exhibit larger surface area to volume ratio. Surface area corresponds to the various properties such as the catalytic reactivity, antimicrobial activity etc... When surface area of the nanoparticles gets increased, their surface energy will be getting increased and hence their biological effectiveness will also be increased (Srivastava et al 2011) Smaller nanoparticles with a larger surface area to volume ratio provide a more effective antibacterial activity even at a very lower concentration. Silver nanoparticles of many different shapes (spherical, rod-shaped, truncated, triangular nanoplates) were developed by various synthetic routes. Truncated triangular silver nanoplates were found to show the strongest anti-bacterial activity. This property could be due to their larger surface area to volume ratios and their crystallographic surface structures.

Nanosilver is a much effective and a fast-acting fungicide against a broad spectrum of common fungi including genera such as Aspergillus, Candida and Saccharomyces. Standard well diffusion method was used to assay the antibacterial activity against human pathogenic bacteria such as Escherichia coli, Pseudomonas aeroginoa, Bacillus subtilis and Klebsiella pneumoniae (Aditi et al 2011). In vitro antibacterial activity of the prepared nanoparticles was studied using the Kirby-Bauer technique, which confirmed the recommended standards of the National Committee for Clinical Laboratory Standards (NCCLS), now known as Clinical and Laboratory Standards Institute CLSI. The agar well diffusion method was used to assess the antibacterial activity of the synthesized Ag nanoparticles. The zone of inhibition produced by various antibiotics were compared with the inhibitory zone produced by the silver nanoparticles, were also demonstrated (Geoprincy et al 2011). Besides, the antibacterial assays were performed on human pathogenic bacteria like Escherichia coli and Pseudomonas
aeruginosa by standard disc diffusion method. Luria Bertani (LB) broth/agar medium was used to cultivate bacteria. Basically, nanoparticle has antimicrobial (including antibacterial and antifungal) applications. The silver or gold nanoparticles that are produced extracellularly from Fusarium oxysporum can be used in several of materials like clothes. Such type of clothes is sterile and is used in hospitals to prevent or to minimize the infection with pathogenic bacteria like Staphylococcus aureus. The average zones of inhibition expressing a profound inhibitory effect was represented as 35 mm in P.aerogenosa, 30 mm in K. pneumonia, 36 mm in S. aureus, 40 mm in S. typhi, 38 mm in S. epidermis and 34 mm in E.coli (Shirley et al 2010).

For the concentration of 20 µg, 40 µg, 60 µg and 80 µg of the nanoparticle, Staphylococcus aureus exhibited characteristic inhibitory zones of 14 mm, 16 mm, 18 mm and 20 mm diameter, where as Enterococcus faecalis exhibited 11 mm, 13 mm, 14 mm and 17 mm diameter of zone of inhibiton respectively (Karthick et al 2011). Rather, nanoparticles were also used in biological detection, controlled drug delivery, optical filters, sensor design etc. With respect to diagnosis, Silver nanoparticles interact with HIV-1 Virus via preferential binding to the gp 120 glycoprotein knobs.

Plants and plant extracts can be effectively used in the synthesis of gold and silver nanoparticles as a greener route. Shape and size control of nanoparticles is easily understood with the use of plants. The nanoparticles extracted from plants are used in many applications for benefit of humans. However, the nanoparticle synthesis mechanism by plants is quite complex to understand. Only some rough ideas are available in their synthesis, such as the reducing agent, proteins and phenolic precipitation. The most promising area of research includes the elucidation of the mechanism of plant-mediated synthesis of silver nanoparticles.
The green synthesis of silver nanoparticles was also carried out using leaf extract of Euphorbia hirta. Further, the silver nanoparticle revealed to possess an effective antifungal property against Candida albicans, C.kefyr and A.niger. The extracts of Lantana camara are used as a reducing agent for the synthesis of silver nanoparticles from silver nitrate. The approximate size of nanoparticles was found out to be 39 - 60 nm from the SEM results. This plant can be grown easily and found in all the regions in India as a decorative plant. Also, synthesis of silver nanoparticles reducing silver ions using the extract of Mentha Piperitaleaves was reported. The so obtained nanoparticles were found to be highly dense and stable with an average size ranging from 7 nm to 50 nm (Upendra et al 2009). Using the fruit extract of papaya plant, the bio-reduction of aqueous Ag+ ions has been demonstrated. These nanoparticles are so eco-friendly and have various applications in wound healing. This makes this method exclusively applicable for the large-scale synthesis of other inorganic materials (nanomaterials).

2.14 CHARACTERISTIC PHYSICO CHEMICAL AND BIOLOGICAL APPLICATIONS OF THE GOLD NANOPARTICLE

Gold nano particles have been widely used in many fields like chemical and biological sensors, electronics, dyes, conductive coatings, catalysis, fundamental research and electron microscopy. Almost every chemical process involves catalysis. Nano particles can efficiently act as catalyst since they have large surface to volume ratio and special binding sites. Nanogold exhibites high catalytic activity in the oxidation and reduction of hydro carbons (Chuan-Jian Zhong & Mathew 2001). Thermo sensitive gold nano paticles have been synthesised and can be potentially fabricated into smart liquid cell windows which turns the transparent windows to opaque at high temperature and block solar heat. Nanoparticles exhibit different
physical and chemical properties from their bulk solid materials. When gold nano particles are conjugated with sachcharide and oligo deoxyribonucleic acid, the combination of organic functionality with dielectric properties of gold nano particles resulted in a new material which can be used as a sensitive colorimeter for the detection of poly nucleotides (Ming-Qing Zhu et al 2004).

Gold nano particles incorporated TiO$_2$ can be used as low cost photovoltaic cell with conversion efficiency of 12%. Also Au- TiO$_2$ is found to be a visible light sensitive photocatalyst (Yang Tion et al 2005). Gold nano particles are non toxic under certain conditions and they do not photo bleach. They can absorb throughout visible and NIR. So gold nano rods are emerging as best alternative to organic fluroscent dyes (Catherine et al 2008). Gold nano particles also posses easy optical tunability, and facile synthesis makes gold nanorods as a most promising nano particle for biomedical imaging and photothermal therapy applications (Prashant et al 2006).

Gold nanoparticles can be used as bio sensors due to its unique optical properties. Anti-EGFR (Epidermal Growth Factor Receptor) Gold nanoparticles conjugated with gold nano particles can distinguish cancerous and non cancerous cells which is proved by SPR (Surface Plasmon Resonance) scattering and SPR absorption spectroscopy. Hence it can be used in cancer diagnostics. Gold nanoparticles plays important role in drug and gene delivery. Gold nanoparticles when irradiated with light in water, it will create local heating and it can be used in photo thermal destruction of tumours. Also gold nanoparticles enhance the efficiency of photothermal therapy by 20 times (Shaojun Guo & Erkang Wang 2009). The excellent biocompatibility and unique properties made gold nano particles as attractive material for bio sensor, chemo sensor and electro catalyst. The electro chemical device with gold nanoparticles will provide a new oppurtunity for gene diagnostics. The electro catalyzation of small molecules such as glucose,
norepineprine, dopamine, catechol, epinephrine and ascorbic acid can be enhanced by gold nano particles. Some toxic substances can be detected by AuNPs derivated electrode (Stefano Pernia et al 2009).

Gold nano particles enhance the hydrophobic properties of polymers. Methylene blue and nano gold are used to make light activated antimicrobial polymers. In the case of microbes like MRSA and *E.Coli*, the most pronounced bacterial kills were found with the polymer containing both methylene blue and nanogold. Light-activated antimicrobial polymers were made from a simple swell-encapsulation-shrink method using methylene blue, nanogold (Akhilesh Raj et al 2010). Cefaclor is a second generation antibiotic of the cephalosporin family. The MICs of gram positive bacteria (*S.aureus*) obtained from cefaclor reduced gold nano particle and cefaclor were found to be 10mg and 50mg respectively. That is why the cefaclor reduced gold nanoparticle were more potent antimicrobial agents against bacteria than cefaclor (Yongwen Zhang et al 2008). The colloidal gold nanoparticles exhibits very good ratios reached 98% with 2.8 μg/mL of gold (Hongwei Gu et al 2003).

Gold nano particles can act as polyvalent inhibitor when it is capped with vancomycin. The composites formed by embedding nano particles shows very good antimicrobial activity against (gram negative) *E.coli* bacteria. This composite film can be used as surface coating and has wide applicions like optical switches, shutters, wave guides, optical filters and in biomedical applications (Sangaraju Shanmugam et al 2006). NGBC can be used to inhibit pesticide and bacterial concentration and hence used in water hygiene management (Sujoy et al 2009). Among the different metal nanoparticles, gold is specifically and extensively used to form Au/TiO$_2$ composites. This composite find its applications in the photocatalytic degradation of aromatic pollutants, organic dyes, azo compounds
(Lidia Armelao et al 2006). Banana peel extract can be used to synthesis gold nano paricles. This banana peel extract derived gold nano particles is simple, low cost, non toxic, eco friendly. This gold nano particles exhibit anti bacterial and anti fungal properties (Ashok Bankar et al 2010). The colourless gold nano particle were derivatised using anti bodies to human chorionic gonadotropin which is a harmone released by pregnant women in urine. When a urine sample containing this hormone is mixed with gold nano particles, the nanoparticles coaggulate to form pink aggregates. Thus gold nano particle is used to conduct home pregnancy test. Also gold nano particles are used as tracers in electron microscope studies of cellular biological compounds (Nguyen Thi et al 2002).