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GREEN SYNTHESIS OF NANOPARTICLES &ITS APPLICATIONS: A REVIEW

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Abstract:
Inrecentyears,areaofmaterialscienceisfocusedtowardsthegreensynthesisofnanoparticlesin ordertofindoutreliable,sustainableaswellasecofriendlytechniqueforsynthesisofmetaland,metal oxidenanoparticles.Livingorganisms,especiallyplantsarewidelyutilizedforgreensynthesis of nanoparticleduetothepresenceof variousphytochemicalsandbiological components(e.g.,flavonoids,alkaloids,terepenoids,amides,andaldehydes)thatactasreducingagentsrendering synthesis of nanoparticles possible. Nanoparticles synthesized through green routesarefaster,easyascomparedtotraditionalmethodsofsynthesis.Moreover,thesenanoparticlesdemonstratemore stability. Thus plants are widely utilized as the source of reducing agents for large scale biosynthesisofnanoparticles.Inthisreview,wehavesummarizedthevariousthefundamentalmethodsfor“greensynthesis”ofmetalandmetaloxide[e.g.,gold(Au),silver(Ag),copperoxide(CuO),and zincoxide(ZnO)]nanoparticlesutilizingnaturalplantproducts,tryingtoexploretheroleofbiologicalcomponents,essentialphytochemicalsasreducingagentsandsolventsystems.Lastly,we have covered applications of biosynthesizednanoparticlesintermsoftheirantimicrobial activity,nanoparticlesinbiomedical,catalysisandbiosensorsfields.

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Keywords: Nanoparticles, green synthesis;reducingagent; antimicrobial property; biosensors.

1. INTRODUCTION

Nanotechnology has emerged as the most importantareaof research in science. Nanotechnology isreferredto„Synthesis,manipulation,andapplication of the structures of nanometer size‟ [1].AJapaneseresearcherfirstintroducednanotechnology, NorioTaniguch [2].The science ofnanotechnology is occupying vastareaof researchinmaterialsciencenowadays,creatingnewernanostructures like nanoparticle, nanotubes andvariousother nanostructureswithtotallynovelpropertiesandvaried .[3]One of the most important area of research innanotechnologydealswithsynthesis,characterization and applicationsof nanoparticles[4].Infacttheoriginandknowledgeofnanotechnology dates back to thousand yearsfromuseofgoldenornamentstouseofgoldnanoparticles for staining drinking glasses to use ofnanoparticles to cure variety of diseases. In short,nanotechnologyencompassesknowledgeofmaterial science along with physics, chemistry andbiologyaimingatitsbiomedicaluse[5]. Greenchemistry(GC) andnanotechnology(NT)togetherareinfluencingandevolvingscientificresearchalongwithenvironmental safety. Togetherboththesefieldsareemergingas„Greennanotechnology‟, which is mainly focused towards thedevelopment of nanoscale, sized entities for enormousapplications [6-9]. Nanoparticles are of different typesincludinginorganicNPsaswell asorganic NPs.Inorganic nanoparticles include non-metallic, metallicand magnetic nanoparticles. Some of the examples ofinorganicnanoparticlesareZnO,ZnS,CdS, andmetallicNPslikeAu,Ag,Cu,Al.Magneticnanoparticles includes Co, Fe, andNi, while organicnanoparticlesmainlyincorporatescarbonNPsnanoparticles like quantum dots, carbon nanotubesand fullerenes. The more elaborated classification ofnanoparticlesisasfollowing[11]-

1. Metals and metal alloys (Au, Ag, Pt, Pd, Cu, Fe, Ni,Co,Al,Mn,Mo)
2. Non-metallicinorganicnanoparticles(TiO_2, SiO_2,ZnO, Al $(OH)_3$, Fe_2O_3, Fe_3O_4, CeO_2, ZrO_2, CaO,ITO,ATO)
3. Nanomaterials based on carbon (fullerenes, carbonnanotubes,carbonnanofibers,graphene)
4. Nanopolymersanddendrimers(polymericnanoparticles,polymernanotubes,nanowiresand nanorods,nanocellulose,nanostructuredpolymerfilms)
5. Quantumdots (Cadmium telluride , cadmium selenideandcadmiumfreequantumdots)

The gold (Au) and silver (Ag) nanoparticlesareareaofinterestofresearchersfrombroaderapplicationpointof view. Increasedemergence ofantibiotic resistance amongst pathogenstoantibioticsincreased it applications as these metallic nanoparticlesdemonstrates promising antibacterial activity due to itshigh surface-area-to-volume ratio. Silver nanoparticlesimpair cell division aswell asrespiratory chain inbacteria. These nanoparticles mostly adhere to bacterialcell membrane and destroy sulphur containing proteinsaswell asbacterial DNAmaking its phosphorouscontaining component as the main target [12]. Thepresentreviewarticlefocusesonvariousgreensynthesis methods used for the synthesis of Silver (Ag),gold(Au),Zincoxide(ZnO)andCopperoxidenanoparticles(CuO)usingplantextracts.Variousbiomedical,environmentalandpharmacologicalapplicationsarealsoreviewed.

2. METHODS FOR SYNTHESIS OF NANOPARTICLES

The field of nanotechnology is most emerging area ofresearch in material science nowadays. Nanotechnologyis defined as „the manipulation of the matter at theatomic or molecular level of 1-100 nm size range.‟ Duetothissmallersizethesubstanceswithsuperiorproperties and applications can be produced, alsothesenanoparticles play bridging role between bulk structuresand molecular structures. [13] Due tovast applicationsin biomedicines, and materials with superior propertieslike good tensile strength, conductivity and superiorrigidity they are on demand in aircraft spares andsatellite parts manufacturing industries also. [14-17]The development of novel methods for the synthesisofstable dispersed nanoparticlesof nanometer sizesandchemical composition is recent challenge in front ofscienceofnanotechnology. Physical and Chemicaltechniques are the most common methods for synthesisofnanoparticles.Physicalmethodsofsynthesisincludessever plasticdeformation,ultrasonic shotpeeling methods, and inert gas condensationmethods.Grinding and pyrolysis processes are mainly employedfor synthesis of metallic nanoparticles. Grinding mainlyinclude reducing the size of macromolecules or micromolecules by size reduction mechanism. In the methodof pyrolysis liquid or gas precursor is forced throughsmallinletsunderhighpressureandoxidizednanoparticles are recoveredfrom it. However physicalmethodfor synthesisof nanoparticlesbearssomedisadvantagesasthe nanoparticles, asit hasbeenreported that this techniques results in production of theparticleslargerthan100nmsize,whichislessconsideredasnanosize.Also physical methodsofsynthesisofnanoparticlesareexpensiveanditsproduction results in losses to environment quality.[18].The chemical methods employed for synthesisofnanoparticles involves a method in which nanoparticlesare synthesized in presence of reducing agents likepotassium bitartrateor sodium borohydride [19]. Inthesetechniquespolyvinyl pyrrolidoneorsodiumdodecyl benzyl sulfate are used as stabilizing agentstopreventtheclumpingoragglomerationofnanoparticles.methoxypolyethyleneglycolorhydrazineare employed for same purpose[20-21].Thechemical methods usedfor synthesisof nanoparticlesare expensive as well as unecofriendly,as it employsuseof toxichazardous chemicals during synthesisposing risk toecosystems. Thus, there istremendousneed of development of cost effective, economical aswellasecofriendlytechniquesforsynthesisofnanoparticles.

2.1 TOPDOWNANDBOTTOMUPPROCESS FORTHE SYNTHESISOF NANOPARTICLES :

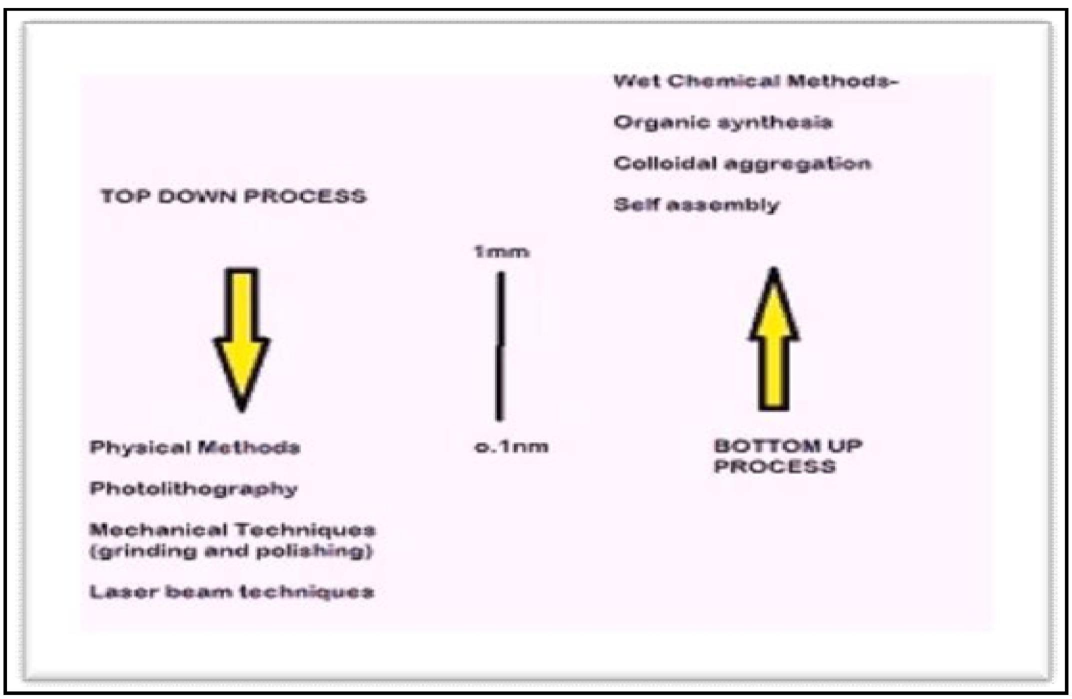

Figure1:Top-downandBottom-upMethodsofNanoparticlesynthesis[22].

Thetopdownprocessof synthesisof nanoparticlesisamongst the physical techniquessynonymouslyreferredasthe micro fabrication technique as it employs tools to cut andresize materials in desired shape and sizes from suitableinitial material. Due to larger sizes of resultant nanoparticles,addition of acid is needed in this process to reduce the size ofNPs.Someofthetechniquesinthiscategoryare-Photolithography, grinding in ball mill as well as etching andsputtering.(Figure1)

2.2 GREEN SYNTHESIS OF NANOPARTICLES:

However, "Bottom up" process is one of the reliable andeffective techniques as compared to "Top down Process".Here, the process initiates from smaller entities at atomiclevel or molecular level withself-assembly. One of thesignificance of this techniques is that- it is possible to keepcheck the size of nanoparticles by varying various factors likeconcentration of precursors and reaction parameters [22].Both of the above methods of synthesis of nanoparticlesinvolve use of toxic chemicalsas well as resulting intoformationofbyproducts,whicharenotsafefrom environment safety point of view. Therefore, to avoid thesedrawbacks,itisimportanttodevelopadvancementoftechniques into the newer, cheaper andecofriendlymethodsof nanoparticle synthesis [23]. Hence, this review article isfocusedongreeninspiredsynthesisofnanoparticles.The un-ecofriendly as well as toxic methods of synthesis ofNPs leads to an urge to develop safer as well as cost effectivemethods for synthesis of nanoparticles. Exploiting greenroutes for synthesis of nanoparticles is one of the options tosolvethisissue. Researchershave found that, naturallyoccuring materials can be employed well for the synthesisofstable NPs. Advancement green of material science togetherwith nanotechnology has enriched the newer dimensionsofbiosynthesisof nanoparticles. Theterm „Green Synthesis‟distinguishesnatural or greenmethodsfrom traditionalphysical and chemical methods. In green synthesismethodsnaturally occuring substances are used as reducing agents forsynthesis of NPs. „Green synthesis‟ is one of the approach forreachinggreenelementsofthenatureforexampleethanobotanical, phytochemicals, materialsderived fromanimalsand biomoleculesfrom microbial origin. The basicadvantagesofgreensynthesismethodsover syntheticmethodscanbeenlistedasbelow-

a. Since natural components are used, it‟s an environmentfriendly approach since no toxic ingredients are involvedduringsynthesis.
b. The natural biological ingredients derived from living thingsact as reducing as well as capping agents, thus it‟s a costeffective technique.
c. Maintenance of external experimental conditions of highenergy and high pressure is not required, thus again its costeffectiveapproach.
d. Large-scaleproductionofnanoparticlesispossible.

Thevariousnaturallyoccuringsourceswhichcanbeemployedforsynthesisofmetalandmetaloxideincludes-

- UseofPlantandPlantExtracts.
- Use of microrganisms (bacteria, fungi, actinomycetesetc.)
- Use of templates like membranes, viruses DNA, anddiatoms.

Althoughuseofmicrorganismsastemplatesareeffective greenermethodsofnanoparticlessynthesis, our reviewdescribes the synthesis of NPs using plant andplant extractsinfurthersections.

3. PLANTEXTRACTMEDIATEDGREENSYNTHESISOF NANOPARTICLES:

3.1 PlantExtractMediatedGreenSynthesisofSilver nanoparticles(AgNps):

Amongstthebiological methods available, use of plantextracts for synthesis of nanoparticles are most suitable asplants are huge reservoir of` easily available metaboliteswhich can actas reducing agents with faster reaction time, ascompared to fungi and several bacteria which needslongertime of incubation during nanoparticle synthesis process forreductionof metal ions[24-26]. In addition, use of plantextracts for synthesis of nanoparticles can occur at lowertemperaturesandrequireslesscontrolledexperimentalconditions. The other advantagesof plant extract mediatedsynthesis of nanoparticles require safe reagents, and can beeasily applied for medicinal, surgical and pharmaceuticalpurposes[27].

The three most ingredients required for green synthesis ofnanoparticlesusingplantextractsincludes - metalsalt,reducingagentandcappingorstabilizingagentforpreventing agglomeration of nanoparticles. Plants are thesourcesofenormousbiomoleculesincludingcarbohydrates,proteins,aminoacids,saponins,phenolicc ompounds,terpenoids, alkaloids,tannins, vitamins and reducing sugarswhich acts asreducing agentsduringstablesnanoparticlesynthesismechanism.Theconcentrationofallthesecomponents in plant describesthe reducing capacity of theplant [28]. The rate of NPs synthesis is dependent on factorslikeamount of plant extract, concentration of metal ions, itspH and temperature [29]. Gardea-Torresdey et al. (2003)usingAlfalfasprouts,reportedthefirstdescriptionofsynthesis of silver nanoparticles. They reported that Alfalfaroots, absorbs silver ions fromagar medium and directs themtowards shoots of this plant in oxidized state. Thuseventualysynthesis of silver nanoparticles occurs (Ag-Np) in shoots[30]. Sadeghi et al. (2015) reported the synthesis of Ag-Npusing *Z.tenuior*plant extract.0.2 grams of dried extract of*Z.tenuior*leaf was added to 50 ml of deionized water, stirredfor around 1hr. and centrifuged .When clear *Z.tenuior*extractwas mixed with0.1mM $AgNO_3$. The silver nanoparticleswereformed.TEMstudiesof thesesynthesizedsilvernanoparticlesrevealedthatAgNpsformedweremonodispersed, spherical in shape with average size of 20nm. Stability studies using zeta potentiometer revealed thatsynthesized AgNps were stable at pH range 6-12. Also FTIRstudies revealed that, proteins fromplant extractsformscoatoversynthesizedAgNpstopreventitsagglomeration,moreover XRD and UV-VIS studies revealed that the leavesextract of *Z.* c*tenuior*can synthesize AgNps[31]. Philip etal. (2011)reported the synthesis of AgNp using *M.uniflorum*leaf extact. Appearance of signatory brown color in reactionmixture revealed the synthesis of Silver nanoparticles inreaction mixture. Characterization studies carried out usingXRD,TEM, UV-Visibleand FTIR studies revealed that silvernanoparticlessynthesizedusing*M.uniflorum*werewelldispersed,anddemonstratedfacecenteredcu bicstructure.AdditionallyFT-IRstudiesrevealedthepresenceoffunctionalgroupsassociatedwithcappingagentsinnanoparticlessolu tion[32].

Sulaimanetal.(2013)inastudyconductedtosynthesizesilvernanoparticlesreportedthat,silvernanopart iclescan be synthesized from *E. Chapmaniana*leavesextractwhen10mlofleavesextractfrom*E.Chapmaniana*was mixed with 0.01mM/ml to 0.02 mM/ml ofaqueous $AgNO_3$ and exposed to sunlight.Charcterizationstudies carried out using XRD studies revealedthe presenceof face centered cubic AgNp, whereas UV-Visible spectrademonstrated silver Plasmon resonance at 413 nm. Thus, *E.Chapmaniana*leavesarecapable of synthesizing silvernanoparticles[33]. In another study, Kumar et.al (2013)reported the green synthesis of silver nanoparticles using*Alternanthera dentata* leaf extract and their antimicrobialactivity. For this, 20ml of 1mMof aqueous solution of$AgNO_3$wereaddedto2mlofleafextractatroomtemperature. Change in color of solution from yellow tobrown indicated the synthesis of silver nanoparticles, whichwere confirmedbysurface plasmonresonance bandat430nm.XRD studies revealed that size of nanoparticles wasfound to be 10-80 nm. Whereas TEM studies demonstratedsize of silver nanoparticles synthesized using thistechniquewere 50-100 nm. FTIR studies indicated that water solublefraction of plant extract*A. dentata* plays crucial role inreduction of precursors involved in synthesis process [34]. Inanotherexperimentongreensynthesisofsilvernanoparticles, Velmurugan et al. (2015) reported that Silvernanoparticles could be synthesized using extract derived frompeanutshells. TEM, XRD and FTIR studies carried outconcludedthatAgNPssynthesizedbythis method areanalogous to that of particles synthesized by commercialmethods. AgNPsrecovered by thismethod were 10-50 nmin size with oval shape [35]. In another study, Bar et al.(2009) reported that, green synthesis of silver nanoparticles ispossible by reducing aqueous solution of $AgNO_3$ by *Jatrophacurcas*extract. This extract also acts as capping agent duringsynthesis [36]. Gavhane et al. (2012) illustrated the synthesisof AgNPs by reducing aqueous salt solution of $AgNO_3$ usingtheextractofNeemandTriphalaleaves.AgNPcharacterization studies like TEM, and nanoparticle trackinganalysis revealed that the silver nanoparticles formed by thistechnique are spherical with diameter in range of 43nm -59nm [37]. Brahma Chari et al. (2014) in a study on greensynthesis of AgNPs using *O. sanctum* leaf extract illustratedthat, when varying concentration of this leaf extract wasadded to different conical flasks containing 45mL of 10−30Msilver nitratesolutioneach, andincubatedunder directsunlight,silver nanoparticle formationwasrevealedbygradualchangeincolorofthesolution. TEMstudiesdemonstratedthat,AgNPsformedwereinnanometersize range [38]. DulenSaikia (2014) (also illustrated the greensynthesis of AgNPs using plant extracts of two medicinalplantsnamely,*Ocimumtenuiflorum*and*Catharanthusroseus*. During the experiment, 5gm of dried leaves of theseplants were added to 100ml of deionized water and boiled for30 min.When extract wasfiltered and added to desiredquantity of aqueous $AgNO_3$andincubated. After incubationappearance of AgNPs were revealed by change in color ofthe solutionfrom brownto dark reddish brown [39]. Inanotherstudy,Vilchis -Nestoretal.(2008)reportedthebiosynthesis of silver as well as gold nanoparticles usingaqueous solution of green tea (*Camellia sinensis*). This studyrevealed that amount of plant extract has a significant role indetermining and controlling the size of silver nanoparticles.Increase in concentration of plant extract in reaction mediumresults in synthesisof nanoparticleswith reduced diameter[40]. One study on *C. zeylanicum* bark extract mediatedsynthesis of AgNPs revealed that the size of biosynthesizedAgNPs varied with concentration of C. *zeylanicum* barkextract [41]. In another study, Awwad and Salem

(2012)illustrated that Mulberry leavesextract can be successfullyutilizedforgreensynthesisofmonodispersedsilvernanoparticleswith average diameter in range of 20 nm.Moreover, these, AgNps demonstrated potential antibacterialactivity against *S.aureus*and *Shigella* sp. [42]. Roy et al.(2017)demonstratedbiosynthesisofAgNPsusing*Azadirachta indica* leaf extract. In this experiment, 1mMsolution of silver nitrate is prepared by adding 0.17 gram of$AgNO_3$ to1000 ml of distilled water in volumetric flask. Fromthis, 100 ml of solution wasused for preparation of Silvernanoparticles. Fresh neem leaves werecollected from neemtree (*Azadirachtaindica*). Fresh and healthy leaves wereplucked and then thoroughly washed under running tap waterto remove the dirt over leaves and then dried over sterilemuslin cloth until water gets removed from surface of leaves.Using sterile knife, these leaves were t h e n finely chopped.20 gramsof these leaves were then added to 100 ml ofsterilized distilled water.The water containing leaves wasthen boiled for around 10 min. The preparation was thencooled and extract is then filtered using sterile muslin clothand stored for preparation of silver nanoparticlesTo preparesilver nanoparticles with neem leaves extract, 5 ml of silvernitrate (1mM) solution is added in each of the separate testtube.Thentoeachofthetesttube5mlneem extractisadded. Allthetubeswerethenincubatedindark chamber tominimizethe photo activation of silver nitrate. Nanoparticleand its color formation is then confirmed by change in colorfrom colorless to brown. The method successfully illustratestheformationofsilvernanoparticles[43]

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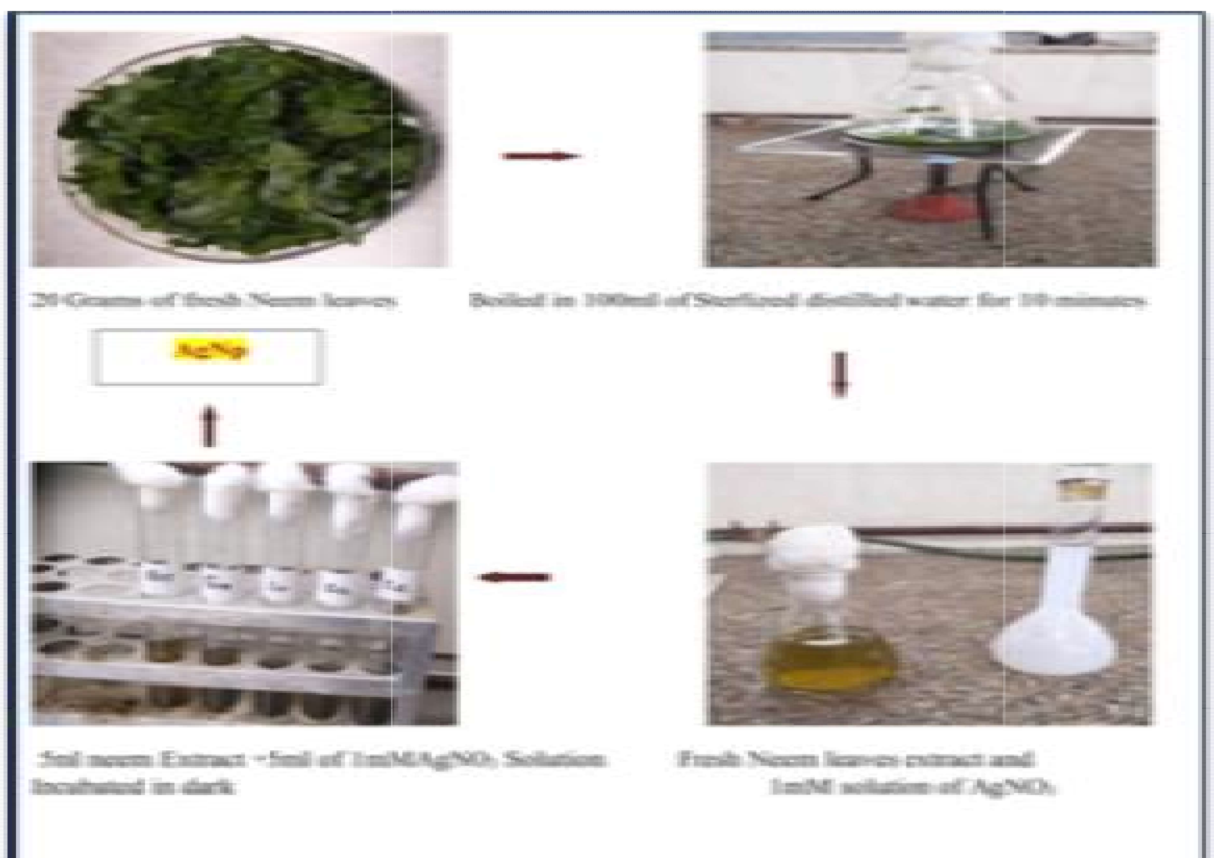

Figure: 2 Green Synthesis of Silver Nanoparticles usingAzadirachtaindicaleafextractusingthemethodofRoyetal.(2017)

Inanattempttosynthesize, silver nanoparticlesusingaqueousextract of turmeric powder as reducing as well ascapping agent. After addition of desired amount of $AgNO_3$ toturmeric extract the appearance of dark reddish brown colordue reduction of $AgNO_3$ after 24 hrs. Characterization studiescarriedoutusing XRD analysis, UV-Visible spectroscopy,FTIRanalysisandTransmissionelectronmicroscopy(TEM).UV-Visiblespectrademonstratedmaximumabsorbance spectra at 432 nm. TEM studies revealed theaverage size of particle size was 18 ± 0.5nm [44]. It has beenreported that Silver nanoparticles could also be synthesizedusing *Magnifera indica, Eucalyptus tereticornis, Caricapapaya,*and*Musa paradisiaca* under desired conditions. Thenanoparticles of different size and shapes in nanometricrangewereobtained.Thusgreensynthesisofsilvernanoparticles utilizing plant extract as reducing and cappingagents isvast and therefore work using*Magnifera indica,Eucalyptustereticornis,Caricapapaya,*and*Musaparadisiaca* under desired conditions.The nanoparticles ofdifferent size and shapes in nanometric range were obtained[45].Thusgreensynthesisofsilvernanoparticlesutilizing plant extract as reducing and capping agents is vast andtherefore work done by various researchers in same line issummarizedasunderinTable1.

Plant	**Precursor**	**Reducing andcappingagent**	**Size(nm)**	**Reference**
Quercus brant	AgNO3	Leaveshydro alcoholic extract	6	[46]
Garlic	AgNO3	Extract	4-6	[47]
Hibiscusrosasinensis	AgNO3	Extract	14	[48]
Cuminumcyminum	AgNO3	Seedspowder	12	(49]
Lantanacamara	AgNO3	Fruitextract	5–12.99	[50]
Peachgum	AgNO3	Peachgumpowder	56±7.87	[51]
Citruslimon	AgNO3	Limonextract	than50	[52]
Tea	AgNO3	Leavesextract	20	[53]
Terminaliaarju	AgNO3	Barkextract	2-100	[54]

na				
Brassicarapa	$AgNO_3$	Leavesextract	16.4	[55]
Solanumtuberosum	$AgNO_3$	Potatoinfusion	1.-12	[56]
Ficuscarica	$AgNO_3$	Leavesextract	13	[57]
Syzygiumcumini	$AgNO_3$	Barkextract	20–60	[58]
wieteniamahogany	$AgNO_3$	Leavesextract	50	[59]
Menthapiperita	$AgNO_3$	Leavesextract	5-30	[60]
Alliumcepa	$AgNO_3$	Extract	33.6	[61]
Magnoliakobus	$AgNO_3$	Leavesextract	16	[62]
Cycas	$AgNO_3$	Leavesextract	2-6	[63]
Cocousnucifera	$AgNO_3$	Flower	22	[64]
Calotropisprocera	$AgNO_3$	Leavesextract	10	[65]
Abutilonindicum	$AgNO_3$	Leavesextract	7-17	[66]
Belgianendive	$AgNO_3$	Leavesextract	75-80	[67]
Ananascomosus	$AgNO_3$	Fruitextract	5-30	[68]
opanaxseptemlobus	$AgNO_3$	Leavesextract	30.8	[69]
Azadirachtaindica	$AgNO_3$	Kernelextract	50-100	[70]
Avenasativa	$AgNO_3$	Stemextract	5-85	[71]
Geranium	$AgNO_3$	Leavesextract	16-40	[72]

Table 1 : Methods for the synthesis of Silver Nanoparticles

3.2 PLANT EXTRACT MEDIAD SYNTHESIS OF GOLD NANPARTICLES:

Nanotechnology is advancing like no other scienceand is making revolution in every aspect of lifer. Along withsilver nanoparticles,researchersare nowadaysfocusingtowards synthesis of gold nanoparticles (AuNps) due to itssuperior properties and applications. Use of phytochemicalsfor synthesis of these gold nanoparticles is of significantimportancedue to reduced environmental safety issuesaswell as its biomedical importance. Plants are reservoirs ofnumberofphytochemicals,whichcanbeexploitedasreducingaswellasstabilizingagentsduringgold nanoparticle synthesis. Therfore this issue is choice of manyresearchers across the globe from last decade. In followingPara, wehave reviewed various methods for green synthesisof gold nanoparticles[73]. Chandran et al. (2014) illustratedin their studies that gold nanoparticles can be synthesizedfromextractsoftwoknownmedicinalplantsnamely*Cucurbita pepo*, and*Malvacrispa*successfully; theyalsoreportedthattheAuNpssynthesizedwerepotentialantibacterial agentsinhibiting the growth of many bacteriaassociatedwith food spoilage [74]. A study conducted byWangetal.(2009)illustratedthat, monodispersedgoldnanoparticleswithdiameter in the range of 5-30 nm can becan be synthesized using extracts of plant *Scutellariabarbata*as reducing and stabilizing agent. The study also concludedthat in plant extractsof *Scutellariabarbata*flavonoids,diterpenoids, alkaloids, steroids and polysaccharides weremain reducing and stabilizing agents [75]. In another study,Raghunandan et al. (2010) reported that gold nanoparticles(AuNps) in diameter range of 5-100 nm can be synthesizedfrom extracts of buds of *Syzygiumaromaticum.* In this studytheyreportedthatthe reduction of salt solution duringsynthesis of AuNps is carried out by flavonoids frombudsof*Syzygiumaromaticum*. [76]. Shankar et al(2003)illustratedthe synthesis of gold nanoparticles with size2.5 to 27.5 nmfromplantextractsof*Pelargoniumroseum(rosegeranium).*[77]. In an experiments carried out on Pear fruitextract for biosynthesis of gold nanoparticles ,Ghodke etal.(2009)illustrated successful synthesis of stable ,triangularshapedAuNps with diameter in the range of 200-500nm, thestudy conducted also proposed that these AuNps can be usedinhexagonalcatalysisandbiosensingprocesses[78]. Shankaretal.(2005)alsoreportedthat,goldnanoparticles can be synthesized using green synthesismethodinwhichplantextractof*Cymbopogonflexuous* (lemongrass) acts as both reducing as well ascapping agent. The size of triangular shaped AuNpssynthesized by this method is in the range of 200-500nm and can find application as infrared-absorbingmaterialinopticalcoatings[81].Indifferentexperiments, Gardea-Torresdeyet al.(2003) illustratedthebiosynthesisof gold nanoparticlesfrom plantextractsof*Medicagosativa*(alfalfa),theAuNpsproducedby thismethod were irregular, tetrahedral,hexagonal platelet, decahedral, icosahedral which findapplicationinlabelinginstructuralbiology,paints[82].Thus, the plant extractsare efficient insynthesizinggoldnanoparticlesfrom plant basedmaterials. Table 2 enlists the variety of plant basedgreensynthesisofgoldnanoparticles.

Plant	**Precursor**	**Reducingand cappingagent**	**Size(nm)**	**Reference**
Emblicaofficinalis	Leafextract	Goldand silver	10–20	85
Coriandrumsativum	Leafextract	Gold	75–57.91	86
Avenasativa	Leafextract	Gold	5–20	87

Nnamomumcamphora	Sundriedleaf	Gold	55-80	88
Garcinia combogia	Fruitextract	Gold	20-100	89
Cocosnucifera	Greencoconut shellextract	Gold	15	90
Magnoliakobus	Leafextract	Gold	5–300	91
Volvariellavolvacea	Extract	Gold	–150nm	92
nacardiumoccidentale	Leafextract	Gold	50-100	93
*Ocimumsanctum*l	Leafextract	Gold	30nm	94
Chenopodiumalbum	Leafextract	Gold	0–30nm	95
Lantanacamara	Leafextract	Gold	100nm	96
Mangiferaindica	Leafextract	Gold	17-20	97
Sorbusaucuparia	Leafextract	Gold	18	98
Stevia rebaudiana	Leafextract	Gold	17	99
Terminaliacatappa (almond)	Leafextract	Gold	21.9	100
Solanumnigrum	Leafextract	Gold	50	101
Terminaliaarjuna	Barkextract	gold	60	102
Pistaciaintegerrima	Leafextract	Gold	50	103
Polysciasscutellaria	Leafextract	Gold	5–20	104
Zizyphusmauritiana	Leafextract	Gold	27	105
Euphorbiahirta	Leafextract	Gold	6-71	106
Pistaciaintegerrima	Leafextract	Gold	20-200	107

Table 2. Methods of Synthesis of Gold Nanoparticles

3.3 PLANT EXTRACT MEDIATED GREEN SYNTHESIS OF ZINCOXIDE(ZnO)NANOPARTICLES:

Zinc oxide may be a useful material as a result of itsdistinctive physical and chemical properties like medicament,deodorizingproperty,highpiezoelectriceffect,semiconductor, giant energy, UV filtering capability etc. ZnOnanoparticles has several application in varied industries likepharmaceutical, chemical, textile, paint, rubber ,packagingindustries etc. apart from this these are currently employed inagriculturalformulations,ecotoxicologicalstudies,environmental fate. They are used for disposal of aquaticweed that is immune to all kind of destruction techniques likephysical, chemical and mechanical [108]. Therefore day byday ZnO NPs demand is increasing. Thereforemanufacturingshould be done ecofriendly methods and it needs to be costeffective. Hence during this review synthesis of ZnO NPs byinexperienced synthesis technique and its applications arereviewed.

Zinc oxide nanoparticlesmaybe synthesized byvariousmethodslike-chemical vapor condensation, arcdischarge, chemical element plasma-metal reactionmethod,and optical maser transmutation within the vapor section,microemulsiontechniques,hydrothermalmethods, sol-gelmethods, sonochemical methods, plant extracts mediatedsynthesis technique, microrganisms mediated synthesis.Outof all the technique of synthesisof nanoparticlesexploitingplant extracts for ZnO synthesis is straightforward, not pricy,andeco-friendly ascompared to ancientsynthesis. Thetraditional chemical synthesismethodspossessdrawbackslikeneedhighpressure-temperatureandtoxicriskysolvents.

Plant extract mediated green synthesis of Zinc oxidenanoparticles(ZnO)eliminatedlotofchemicalprocess and also and limits the utilization of costly andcyanogenicchemicals.Henceresearchersarespecializingininexperiencedsynthesisofnanoparticles.Anotherbenefitofplantextractmediated synthesis is that they are a lot of stable andalsothe rateofsynthesis is quicker than withinthe case of microorganisms .Moreover,the nanoparticlesobtained by plant extract mediatedsynthesisarevariable in forms ofsizeand shapesas compared with those synthesized by usingotherdifferentapproaches.

Thus,thesenumerousbenefits of plantandplant-derivedmaterialsfor synthesis ofZincoxidenanoparticleshaveinterestedresearchers analyzemechanisms of metal ions uptake and bio reduction byplants, and to know the mechanism behind its synthesis.[109].Plants aretheforemostcommonbiologicalsubstrate used for the ecofriendly green synthesis ofnanoparticles with metal like ions[110-111]. Plants areabundant sources of cost effective, non-toxicnaturalreducing agents. During green synthesis processes,these natural reducing biochemicals from plantscan beeasy mechanisms of extraction like treating the plantmaterial to easily available solvents likeH_2O or alcohols.[112]Different components oftheplants are utilized for green synthesis of ZnONps mostof which comprised of leaves, roots, seedsand fruits.The extracts prepared from these plant sources act asreducing agents during biosynthesis processes.[113-116] Nath et al. (2014) reported that Margosa plant canbe utilizedfor biosynthesis of zinc oxide nanoparticles(ZnO) as it is the rich source offlavanones,terpenoidsand reducing sugars, the constituents of the tree leafbroth. They illustrated that, the organic componentsinleafbrothofMargosaplantareresponsibleforreduction of zinc oxide to ZnO NPs as well as itsstabilization [117].ZincoxideisalsoknownasPhilosopher‟swool synonymously. Noorjahan et al. (2015) reported the green synthesis ofsynthesize philosopher's woolnanoparticles(ZnONps)from leaf extract of Margosa plant. When these ZnONps werecharacterized by SEM and FTIR techniques.In FTIR analysis was revealed that ZnO NPs wereencircledbyplantderivedterepenoidsketones,aldehydesand acidswhichsuggesttheirroleasstabilizingas well as capping agents .SEM studiesshowedstable philosopher'swool Nanoflakesandspindle formed nanoparticles. The dimensions of theZnO nanoparticles synthesized were found to 50 nm insize[118].Mariametal.(2014)reporteda unique synthesis for InO3 and ZnO Nanoparticleswithparticle sizeswithinthevaryoftentothirtynmexploitationmetalnitrateand Zn nitrate solutions. TheyusedAloe Vera extractasasolvent rather than organicsolvents. [119]Inanother study, Singhet al. (2018)illustratedthe effectof variation in concentration of plant extract and zincprecursor, incubation time andtemperature of reactionin a study of the biosynthesis of ZnONps using *Ecliptaalba* leaves extract. Inthis study they reported that,ZnoNps formation turned moreuniform and smallerafterincreasing zinc acetate concentration (1.0–5.0mM).[120]Thesefindingswerefoundtobeinagreement with studies of AinSamat et al. (2013) inthisstudy, for synthesisof ZnO NP sfrom *Citrusaurantifolia*extracttheincreaseofzincacetateconcentration resulted inenhanced size uniformityandreduced size of newly formednanoparticles[121].Matinise et al. (2017) reported the study in which*Moringa oleiferea*leaves extract componentsreactswiththe zinc (II) ions which formed zinc oxide after acalcination process. These researchers studied the effectof plant extract mediated synthesis on ZnO nanoparticlesynthesisat different temperatures. The FTIR studiesrevealedthatZnONPssynthesizedat100ºCdemonstrated hydroxyl (–OH) stretching bandswhichwas indicative of formation of zinc complexes withantioxidantsinsynthesisprocess.[122].Nathetal.(2013)reportedthegreensynthesisofZnOnanoparticles from leaf extractof *Azadirachtaindica.*In this study they suggested that, neemplantleaves arepotential source of flavones, terepenoidsandreducingsugars.Andaldehydegroupsareresponsibleforreduction as well as stabilization of zinc oxide to zinc oxide nanoparticles [123]. Raut et al.(2013) reportedthegreensynthesisofZincoxidenanoparticlesmediated by leaves extract of *OcimumTenuiflorum*plant .The constituents present in plant extract act asreducingagents.ThesynthesizedZincoxidenanoparticles were characterized by X-Ray diffraction(XRD),scanningelectronmicroscope(SEM)technique, Fourier Transform Ray diffraction (XRD),scanning electron microscope (SEM) technique, FourierTransform Infrared Spectroscopy(FTIR).Theaveragesize of ZnONps obtained by this method were 13.86nm [124]. In following table 3 wehave summarizedthe various plant based green synthesis methods forZnONPbiosynthesis.

Plant	**Precursor**	**Reducingand cappingagent**	**Size (nm)**	**Refer ences**
Aloevera leaves	ZincNitrate (NS)	Leavesextract	25	125
Lycopersico nesculentum	ZincNitrate (NS)	Fruitextract	40-100	126

Peganum harmala	ZincNitrate (NS)	Seedextract	40	127
Stevia rebaudiana	ZincAcetate (ZA)	Leavesextract	50	128
Hibiscus subdariffa	ZincAcetate (ZA)	Leavesextract	190-400	129
Costus woodsonii	ZincNitrate (NS)	Seedextract	20-25	130
Citrus sinensis	ZincNitrate (NS)	Peelextract	12	131
Couroupita guianensis	ZincAcetate (ZA)	Leavesextract	15-25	132
Mentapulegium	ZincNitrate(NS)	Leavesextract	38-49	133
Simarauba glauca	ZincNitrate (NS)	Leavesextract	NS	134
Vitexnegundo	ZincNitrate (NS)	Leavesextract	NS	135
Solanum nigrum	ZincNitrate (NS)	Leavesextract	29	136
Jacaranda mimosifolia	ZincNitrate (NS)	Flowerextract	2-4	137
Parthenium hysterophorus	ZincNitrate (NS)	Leavesextract	27-84	138
Anisochilus carnosus	ZincNitrate (NS)	Leavesextract	20-40	139
Petroselinumcrispum	ZincNitrate (NS)	Leavesextract	70	140

Table3:PlantExtractMediatedGreenSynthesisofZincoxideNanoparticlesfromSome

3.4 PLANTEXTRACTMEDIATEDGREENSYNTHESISOFCOPPEROXIDENANOPARTICLES:

In recent past years synthesis of nano particles utilizinggreensynthesismethodshasattainedenormousimportanceduetonumerousadvantagesoverconventional chemical andphysic al methods. Plantare widely distributed across the world, are rich sourceof uncountable number of phytochemicals as well aseasily available and processible [141].Copper oxidenanoparticleareimportantduetonumerousapplications as antimicrobial agents, and also used inbatteries, super conductors, andgassensors.

Copperoxidenanoparticlesarealsousedasantifoulingagent"santibacterial, purifiers, algaecides, fungicide[142-144].Thesynthesisofcopperoxidenanoparticlesusing inactivated plant tissue, plantextracts,exudates,andotherpartshasattractednumerous researchers [145]. Its a need to developecofriendly and economic methods to synthesize metaloxide nano particles as there is rapid urbanization,industrializaríanandpopulationgrowth,hencedemand of nanoparticle in different industries is alsoincreasing tremendously. To fulfill this demand Greensynthesis of metal oxide nanoparticles is best method.Single step green synthesis process can be used toprepare nano particles from metal ions. This can behappened as plant extracts contain biomolecules whichreduce metal ions to nanoparticles. This is a very rapidprocess,canbe conducted at room temperature andpressure,easytoperform.Itisecofriendlyandeconomic also. Reducing agents are the biomoleculespresent in plants as their metabolites like alkaloids,phenolic compounds, terepenoids etc. and coenzymes[146].

K.RayapaReddystudiedthegreenapproach of CuO NPssynthesis using *Calotropis procera*(easily found in India)which belongs to the *Asclepiadaceous* family *Calotropisprocera*usedinthemanytreatmentslikediseasesofspleen,piles, tumors, etc. These NPs are widely used in manyapplications such as catalysisbecause of their narrow bandgap,usedin photo catalytic properties[147-148]. Alaa Y.Ghidan*et al*. (2017) reported the green synthesisof copperNPs using *Punica granatum* peels extract. *Punicagranatum*fresh peels were obtained and washed for several times.Powder was prepared from dried peel of *P.granatum*andadded to sterile distilled water and this mixture was boileduntil appearanceof yellow color. ThenCuO NPsweresynthesized,forthiscopperacetatepowderwasdissolvedin thewaterandstirredwithmagneticstirrer.Then*P.granatum* extract was added to the stirred solution;it givesgreen color to the solution and eventually it turned to brownwhichshowstheformationofmonodispersedCuNPs.[149]

Synthesisof CuO NPsfrom *Abutilon indicum wasillustratedby*Ijaz et al. (2018)They collected freshleavesof *Abutilonindicum* andwashed gently toremove dust particles as well as dried and shaded parts.Then the leaves were pulverized and sieved using a200-nm mesh sieve to be used as fuel. They preparednano particles by green combustion method with leavesextract of *A.indicum*as a fuel. To synthesize CuO NPs,Copper (II) nitrate trihydrate was mixed with *Abutilonindicum* extract in double-distilled water. Homogenizedsolution was prepared by constant stirring for 2–5 minusing a magnetic stirrer. Combustion reaction wasperformed on the mixture using a pre-heated mufflefurnace at the temperature 400 ± 5 °C to produce CuONPs.Theashcontentsoftheplantextractswasremoved by filtration. The solution wasfirst washedwithdistilledwater,thenbymethanol to removeimpurities. Then CuONps were calcinated for 2 hrs toget pure form. This pure fine black CuONps can bestored in an airtight container for further use.[150] Fewof the plant extract mediated synthesis processes forCuOnanoparticlesarelistedinfollowingtable4-

Nameofplant	**Part used**	**Precursor**	**References**
AloeVera	Leaves	Copper Sulphate	151

Azadirachtaindica	Leaves	Cupricacetate(monohydrate)	152
Caloropis procera	Leaves	Cupric acetate	153
Euphorbiaesula	Leaves	Copperchloride dihydrate	154
Punica granatum	Peelsof fruit	copper sulfate	155

Table 4: Plant Extract mediated n Green Synthesis ofCopperoxideNanoparticles

4. APPLICATIONS OF Ag, Au, ZnO, CuONANOPARTICLES:

Due to inhibitory action on pathogensSilver nanoparticles(Ag-NPs) are broadly used as the antibacterial and antifungalagents in the form of protective coatings over biomedicalinstruments inclusive of wounddressings, catheters, dentalcomposites, aswell asin certain implantsemployed incardiovasculartreatments.Silvernanoparticlesarealsousedasnano-bio sensing materialsaswell as in agriculturalengineering products [156]. Prosthetic Silicone valve coatedwith Ag-NPs was the first cardiovascular device. The role ofAg-NPcoatinginthisdevicewastoreduce or avoidmicrobial contamination in order to reduce the chances ofinflammatoryreactions. AgNpsalsousedasprotectivesurface coatings on stents as AgNPs are antibacterial as wellas antithrombogenic in nature [157]. It has been also reportedthat use of Silver nanoparticlesin Ag-Npsinto orthodonticadhesive enhances device strengthincreasingresistance tobacteria[158]. Ag-Np coated dressings are used in wounddressings as potent antibacterial agent to treat burns, chroniculcers, pemphigus, and toxic epidermal necrosis[159]. It hasbeen also reported that combination of Chitosan Ag-NPsused in wounddemonstrated potential antibacterial activityas compared to essentially 1% Ag sulfadiazine alongside thedeposition of less Ag.[160] Roe et al. (2008); Hussain et al.(2006);andChouetal.(2008)reportedthat,silvernanoparticles are used as antibacterial coating over catheters.ClassofPolyurethanecathetersiscoatedwiths ilvernanoparticleswhichareantibacterialcatheters[160-162].Silver nanoparticles are used in Electronic componentsandtransportationasSensors, electrodes and integratedcircuit[163-165] .Other than this silver nanoparticles findsenormous applications in environmental applications like airdisinfection,wastewatertreatment,drinkingwaterpurification ,ground water disinfection.[166-169].Also Ag-Nps finds application inNeutraceuticals, food safety andfoodpackaging[170-172].Ithasbeenreportedthat,nanoparticles are the most accurate agentsfor drug deliveryaswellascancertherapy.Incancertherapythesenanoparticlesare successful in overcoming the drawbackscaused by traditional chemotherapeutic agents as these agentswere not accurate enough in targeting the cancerous cells.NowadaysbiobasednanoparticlesarefilledwithchemotherapydrugsandattachedtoRNAlikestructures.Thesenanoparticleswithchemotherapeuticdrugsaccurately targets the cancerous cells and releases the drugsinto cancercells [173].Das et al. (2013) & Alt et al.

(2004) reported thatplant mediated nanoparticles are effective against variouscancer cell lines such as Hep 2, HCT 116 and Hela cell lines.Theenhancedcytotoxiceffectisduetosecondarymetabolites .The plant material based nanoparticles playsactive role in regulating the cell cycle [174-175]. Russier-Antoineet al. 2008 reported that, gold nanoparticles couldbind with negatively charged DNA molecules substitutingcitrateionsresultingintoformationofnovelDNA-nanoparticle .such probes are used in diagnosis of pathogenicand genetic diseases.[176]Huang et al. 2008 illustrated that,gold nanoparticles coupled antigen can used for diagnosticpurposes. Antigen conjugates gold nanoparticles biconjugateswithantibodies.Thus,Biosensorsforimmunoassaysin humanserumhavebeendevelopedfromgoldnanoparticles.[177] GoldnanoparticlesstabilizedbyPhthalocyaninedemonstrated a potential delivery vehicle for photodynamictherapy. [178] Besides these Gold nanoparticles are alsoemployedasbiosensorsbycouplingwith GDP moleculesand also as an immunosensors. Gold nanoparticles have beenin active use in the identification of chemical and biologicalagents The visualization methods with the use of GNP andoptical microscopy [179]. Zinc oxide (Zn O) nanoparticleshave numerous bio applications. It has been reported thatdrug metronidazole benzoate has much effect on biologicalmembranes[180].As ZnO nanoparticleshaveessential blueandnear-Emission,theseareusedincellular imaging.Several studies have reported that,ZnO nanoparticles are usedforcancercellimaging,transferrin-conjugatedgreenfluorescentZnONPswereutilizedwithleastcytotoxicity[181].

Zinc oxide nanoparticles have found to play significantrole ineffecint gene delivery. ZnOQDs were layered usingpositivelychargedpoly(2-(dimethylamino)ethylmethacrylate)(PDMAEMA) polymers which are utilized forcondensingpDNAforgenedelivery[182]. ZnO nanomaterials variousdesirable characteristics likesemiconductingpropertiessuchasbiosensing,strongadsorptioncapability,highisoelectricpoint,andhighcatalytic efficiency (IEP; ~9.5) which are appropriate foradsorption of certain proteins such as antibodies and enzymeswith less IEPs by electrostatic interaction[183]. Along withsilver nanoparticles copper oxide nanoparticles (CuO)aremost frequently used antimicrobial agents due to their killingeffectonpathogens.IthasbeenreportedthatCuOnanoparticles has capacity to kill more than 99.9% of Gram-positive andnegative bacteria within 2 hrs. of exposure ,ifdesired dose is administered or applied. In Several studies ithasbeenreportedthat, CuO nanoparticlesreducesthechances of nosocomial infections. Nanoparticlescoatedbedsheets is considered to be one of themostrecentinnovationin health care practices in order to reduce the chance ofacquiringnosocomialinfections[184].Copperoxidenanoparticles also show considerable antifungal properties aswell as effectiveagainst biofilmdevelopment. Due to woundhealing activity CuO nanoparticlesare also incorporated inwounddressings[185-186].

Note:Allfiguresusedinthisarticlearecreatedbyauthors**.**

REFERENCES:

1. Sarsar V, Selwal KK, Selwal K. 2013. Green synthesis of silver nanoparticles using leaf extract of Mangifera indica and evaluation of their antimicrobial activity. J Microbiol Biotech Res. 3:27–32.

2. Taniguchi N (1974) on the basic concept of nanotechnology. In: Proc. of International

Conference on Precision Engineering (ICPE), Tokyo, Japan, 18– 23

3. Jahn W. 1999. Review: chemical aspects of the use of gold clusters in structural biology. J Struct Biol. 127:106–112.

4. Rao PV., et al. “Recent advances in nanotechnology- based diagnosis and treatments of diabetes”. Current Drug Metabolism 16.

4 .Sanjeeb KS and Vinod L. “Nanotech approaches to drug delivery and imaging”. Drug Discovery Today 8.24 (2003): 1112-1120.

5. Ahluwalia V (2006) Green chemistry: environmentally benign reaction. Ane Books Pvt. Ltd, New Delhi

6. Anastas PT, Perosa A, Selva M (2014) Handbook of green chemistry, green processes, green Nano science, Vol 8. Wiley, Hoboken

7. Anastas PT, Horva ́th IT (2011) Green chemistry for a sustainable future. Wiley-Blackwell, Hoboken

8. Feynman RP (1960) there‟s plenty of room at the bottom. Eng. Sci 23(5):22–36

10.Vadlapudi and Kaladhar 2014Green synthesis of silver and gold nanoparticles. Middle East J Sci Res. 19:834–842.ful flexibility.

9. Nanomaterials, The global market, Forecast from 2010 to 2025, Future markets, Edition. 2, February (2015).

10. Rai M, Yadav A, Gade A. Silver nanoparticles as a new generation of antimicrobials. Biotechnology Advances. 2009; 27(1):76-83.

13. M.Karkare, Nanotechnology Fundamentals and Applications, IK International Publication, 2008

11. Issa B, Obaidat I, Albiss B, Haik Y. Magnetic Nanoparticles: Surface Effects and Properties Related to Biomedicine Applications. International Journal of Molecular Sciences. 2013;14(11):21266-305.

12. 15.Rao CNR, Ramakrishna Matte HSS, Voggu R, GovindarajA.Recent progress in the synthesis of inorganic nanoparticles. Dalton Transactions. 2012;41(17):5089.

13. Pradeep T. Nano: The Essentials: McGraw-Hill Education; 2008.

14. Zeiri Y, Elia P, Zach R, Hazan S, Kolusheva S, Porat Ze. Green synthesis of gold nanoparticles using plant extracts as reducing agents. International Journal of Nano medicine. 2014: 4007.

15. Li Y, Duan X, Qian Y, Yang L, Liao H. Nano crystalline Silver Particles: Synthesis, Agglomeration, and Sputtering Induced by Electron Beam. Journal of Colloid and Interface

Science. 1999;209(2):347-9
16. Tan Y, Dai X, Li Y, Zhu D. Preparation of gold, platinum, palladiumand silver nanoparticles by the reduction of their salts with a weak reluctant– potassium bitartrate. Journal of Materials Chemistry. 2003; 13(5):1069-75.

17. 20.Li Y, Duan X, Qian Y, Yang L, Liao H. Nano crystalline Silver Particles: Synthesis, Agglomeration, and Sputtering Induced by Electron Beam. Journal of Colloid and Interface Science. 1999;209 (2):347-9.

18. Mallick K, Witcomb MJ, Scurrell MS. Polymer stabilized silver nanoparticles: A photochemical synthesis route. Journal of Materials Science. 2004; 39(14):4459-63.

19. Sci. Tot. Environ. Vol. 400 (1-3), Ju-Nam, Y. and Lead, J.R., Manufactured nanoparticles: An overview of their chemistry, interactions and potential environmental implications, pp396-414,
20. Ahmed S, Ahmad M, Swami BL, Ikram
a. S. 2016b. A review on plants extract mediated synthesis of silver nanoparticles for antimicrobial applications: a green expertise. J Adv Res. 7:17–28.
21. Fardood ST, Ramazani A, Moradi S. A Novel Green Synthesis of Nickel Oxide Nanoparticles Using Arabic Gum. Chemistry Journal of Moldova. 2017; 12(1):115-8.

14. Issa B, Obaidat I, Albiss B, Haik Y. Magnetic Nanoparticles: Surface Effects and Properties Related to Biomedicine Applications. International Journal of Molecular Sciences. 2013;14(11):21266-305.
15. Rao CNR, Ramakrishna Matte HSS, Voggu R, GovindarajA.Recent progress in the synthesis of inorganic nanoparticles. Dalton Transactions. 2012;41(17):5089.

16. Pradeep T. Nano: The Essentials: McGraw-Hill Education; 2008.
17. Zeiri Y, Elia P, Zach R, Hazan S, Kolusheva S, Porat Ze. Green synthesis of gold nanoparticles using plant extracts as reducing agents. International Journal of Nano medicine. 2014: 4007.

18. Li Y, Duan X, Qian Y, Yang L, Liao H. Nano crystalline Silver Particles: Synthesis, Agglomeration, and Sputtering Induced by Electron Beam. Journal of Colloid and Interface Science. 1999;209(2):347-9
19. Tan Y, Dai X, Li Y, Zhu D. Preparation of gold, platinum, palladiumand silver nanoparticles by the reduction of their salts with a weak reluctant– potassium bitartrate. Journal of Materials Chemistry. 2003; 13(5):1069-75.

20. 20.Li Y, Duan X, Qian Y, Yang L, Liao H. Nano crystalline Silver Particles: Synthesis, Agglomeration, and Sputtering Induced by Electron Beam. Journal of Colloid and Interface Science. 1999;209 (2):347-9.

21. Mallick K, Witcomb MJ, Scurrell MS. Polymer stabilized silver nanoparticles: A photochemical synthesis route. Journal of Materials Science. 2004; 39(14):4459-63.

22. Sci. Tot. Environ. Vol. 400 (1-3), Ju-Nam, Y. and Lead, J.R., Manufactured nanoparticles: An overview of their chemistry, interactions and potential environmental implications, pp396-414,

23. Ahmed S, Ahmad M, Swami BL, Ikram
S. 2016b. A review on plants extract mediated synthesis of silver nanoparticles for antimicrobial applications: a green expertise. J Adv Res. 7:17–28.

24. Fardood ST, Ramazani A, Moradi S. A Novel Green Synthesis of Nickel Oxide Nanoparticles Using Arabic Gum. Chemistry Journal of Moldova. 2017; 12(1):115-8.

25. Ali Ramazani STF, Zahra Hosseinzadeh, Fariba Sadri, Sang Woo Joo. Green synthesis of magnetic copper ferrite nanoparticles using tragacanth gum as a bio template and their catalytic activity for the oxidation of alcohols. Iranian Journal of Catalysis. 2017; 7:181-5.

26. Ankamwar B, Chaudhary M, Sastry M. Gold Nanotriangles biologically synthesized using Tamarind Leaf Extract and Potential Application in Vapor Sensing. Synthesis and Reactivity in Inorganic, Metal-Organic, and Nano-Metal Chemistry. 2005;35(1):19-26.

27.. Abdel-Halim ES, El-Rafie MH, Al-Deyab SS. Polyacrylamide/guar gumgraft copolymer for preparation of silver nanoparticles. Carbohydrate Polymers. 2011;85(3):692-697.

28. Ledwith DM, Whelan A M, Kelly JM. A rapid, straightforward method for controlling the morphology of stable silver nanoparticles. Journal of Materials Chemistry. 2007;17(23):2459.

29. Han KN, Kim NS. Challenges and opportunities in direct write technology using nano-metal particles. KONA Powder and Particle Journal. 2009; 27: 73-83.

30. Gardea-Torresdey JL, Gomez E, Peralta-Videa JR, Parsons JG, Troiani H, Jose-Yacaman M. 2003. Alfalfa sprouts: a natural source for the synthesis of silver nanoparticles. Langmuir. 19:1357–1361.

31 B. Sadeghi F.Gholamhoseinpoor., A study on the stability and green synthesis of silver nanoparticles using Ziziphoratenuior (Zt) extract at room temperature., Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy ., Volume 134, 5 January 2015, Pages 310-315

32. Vidhu, V. K., Aromal, S. A., & Philip, D. (2011). Green synthesis of silver nanoparticles using Macrotyloma uniflorum. Spectrochimica acta. Part A, Molecular and biomolecular spectroscopy, 83(1), 392–397.

33. Sulaiman, G. M., Mohammed, W. H., Marzoog, T. R., Al-Amiery, A. A., Kadhum, A. A., & Mohamad, A. B. (2013). Green synthesis, antimicrobial and cytotoxic effects of silver nanoparticles using Eucalyptus Chapmaniana leaves extract. Asian Pacific journal of tropical biomedicine, 3(1), 58–63. https://doi.org/10.1016/S2221-1691 (13)60024-6

34. Kumar D.A., Palanichamy V., Roopan S.M. (2014) Green synthesis of silver nanoparticles using Alternanthera dentata leaf extract at room temperature and

their antimicrobial activity .Spectrochimica Acta - Part A: Molecular and Biomolecular Spectroscopy, 127 , pp. 168- 171.

35. Velmurugan P, Sivakumar S, Young-Chae S, Seong-Ho J, Pyoung-In Y, Jeong-Min S, et al. 2015. Synthesis and characterization comparison of peanut shell extract silver nanoparticles with commercial silver nanoparticles and their antifungal activity. J Ind Eng Chem. 31:51–54.

36. Bar H, Bhui DK, Sahoo GP, Sarkar P, Pyne S, Misra A. 2009. Green synthesis of silver nanoparticles using seed extract of Jatropha curcas. Colloids Surf APhysicochemEng Asp. 348:212–216.

37. Gavhane AJ, Padmanabhan P, Kamble SP, Jangle SN. 2012. Synthesis of silver nanoparticles using extract of neem leaf and triphala and evaluation of their antimicrobial activities. Int J Pharm Bio Sci. 3:88–100

38. Goutam Brahma Chari, Sajal Sarkar, Ranjan Ghosh, Soma Barman, Narayan C Mandal, Shyamal K Jash, Bubun Banerjee and Rajiv Roy "Sunlight-induced rapid and efficient biogenic synthesis of silver nanoparticles using aqueous leaf extract of Ocimum sanctum Linn. With enhanced antibacterial activity" Organic and Medicinal Chemistry Letters, 2014; 4.

39 DulenSaikia, "Green Synthesis And Optical characterizations Of Silver Nanoparticles" International Journal of Latest Research in Science and Technology ISSN (Online):2278-5299, March-April, 2014; 3(2): 132-135

40. Vilchis-Nestor AR, Sánchez-Mendieta V, Camacho-López MA, Gómez-Espinosa RM, Camacho-López MA, Arenas Alatorre JA. Solventless synthesis and optical properties of Au and Ag nanoparticles using Camellia sinensis extract. Materials Letters. 2008;62(17):3103-5.

41. Sathishkumar M, Sneha K, Won SW, Cho CW, Kim S, Yun YS. Cinnamon zeylanicum bark extract and powder mediated green synthesis of nano-crystalline silver particles and its bactericidal activity. Colloids and Surfaces B: Bio interfaces. 2009; 73(2):332-8

42. Awwad AM, Salem NM. 2012. Green synthesis of silver nanoparticles by mulberry leaves extract. NanosciNanotechnol. 2:125–128.

43. Roy, P., Das, B., Mohanty, A., & Mohapatra, S. (2017). Green synthesis of silver nanoparticles using Azadirachta indica leaf extract and its antimicrobial study. Applied Nano science, 7(8), 843-850.

44. Alsammarraie, Fouad K.; Wang, Wei; Zhou, Peng; Mustapha, Azlin; Lin, Mengshi ; Green synthesis of silver nanoparticles using turmeric extracts and investigation of their antibacterial activities; Colloids and surfaces. B, Bio interfaces, ISSN: 1873-4367, Vol: 171, Page: 398-405

45. A. Mohanty, S. Mishra, R. Bosu, U. K. Maurya, S. P. Netam, and B. Sarkar, "Phytoextracts -synthesized silver nanoparticles inhibit bacterial fish pathogen Aero monas

hydrophila," Indian Journalof Microbiology,vol.53,no.4,pp.438–446,2013.

46. Korbekandi H, Iravani S, Abbasi S. 2012. Optimization of biological synthesis of silver nanoparticles using Lactobacillus casei subsp. casei. J Chem Techno Biotechnol. 87:932–937.

47. Von White G, Kerscher P, Brown RM, Morella JD, McAllister W, Dean D, et al. 2012. Green synthesis of robust, biocompatible silver nanoparticles using garlic extract. J Nanomater. 2012: 55.

48. Philip D. 2010a. Green synthesis of gold and silver nanoparticles using Hibiscus rosa sinensis. Phys E Low Dimens Syst Nanostructure. 42:1417–1424.

49. Kudle KR, Donda MR, Alwala J, Koyyati R, Nagati V, Merugu R, et al. 2012. Bio fabrication of silver nanoparticles using Cuminumcyminumthrough microwave irradiation. Int J Nanometer Biostruct. 2:65–69.

50 Sivakumar P, Nethradevi C, Renganathan S. 2012. Synthesis of silver nanoparticles using Lantana camara fruit extract and its effect on pathogens. Asian J Pharm Clin Res. 5:97–101

51. Yang N, Wei XF, Li WH. 2015. Sunlight irradiation induced green synthesis of silver nanoparticles using peach gumpolysaccharide and colorimetric sensing of H2O2. Mater Lett. 154:21–24.

52.Prathna T, Chandrasekaran N, Raichur AM, Mukherjee A. 2011. Biomimetic synthesis of silver nanoparticles by Citrus limon (lemon) aqueous extract and theoretical prediction of particle size. Colloids Surf B Bio interfaces. 82:152–159.

53.Sun Q, Cai X, Li J, Zheng M, Chen Z, Yu C-P. 2014. Green synthesis of silver nanoparticles using tea leaf extract and evaluation of their stability and antibacterial activity. Colloids Surf APhysicochemEng Aspects. 444:226–231.

54.Ahmed Q, Gupta N, Kumar A, Nimesh S. 2016a. Antibacterial efficacy of silver nanoparticlessynthesized employing Terminalia arjuna bark extract. Artif Cells NanomedBiotechnol. doi:10.1080/21691401. 2016.1215328.

55.Narayanan KB, Park HH. 2014. Antifungal activity of silver nanoparticles synthesized using turnip leaf extract (Brassica rapa L.) against wood rotting pathogens. Eur J Plant Pathol. 140:185–192.

56 Roy K, Sarkar C, Ghosh C. 2015. Photocatalytic activity of biogenic silver nanoparticles synthesized using potato (Solanum tuberosum) infusion. Spectrochim Acta Part A Mol BiomolSpectrosc. 146:286–291.

57. Geetha N, Geetha T, Manonmani P, Thiyagarajan M. 2014. Green synthesis of silver nanoparticles using Cymbopogancitratus (Dc) Stapf. Extract and its antibacterial activity. Aust J Basic Appl Sci. 8:324–331.

58. Prasad R, Swamy VS. 2013. Antibacterial activity of silver nanoparticles synthesized by bark extract of Syzygiumcumini. J Nanopart. 2013:1–7.

59. Mondal S, Roy N, Laskar RA, Sk I, Basu S, Mandal D, et al. 2011. Biogenic synthesis of Ag, Au and bimetallic Au/Ag alloy nanoparticles using aqueous extract of mahogany (Swietenia

mahogani JACQ.) leaves. Colloids Surf B Biointerfaces. 82:497–504.

60. Parashar UK, Saxena PS, Srivastava A. 2009. Bioinspired synthesis of silver nanoparticles. Digest J NanomaterBiostruct (DJNB).

61. Saxena A, Tripathi R, Singh R. 2010. Biological synthesis of silver nanoparticles by using onion (Allium cepa) extract and their antibacterial activity. Dig J Nanomater Bios. 5:427–432.

62.Song JY, Kwon E-Y, Kim BS. Antibacterial latex foams coated with biologically synthesized silver nanoparticles using Magnolia kobus leaf extract. Korean Journal of Chemical Engineering. 2012;29(12):1771-5

63. Jha AK, Prasad K. Green synthesis of silver nanoparticles using Cycas leaf. International Journal of Green Nanotechnology: Physics and Chemistry.
2010;1(2):P110-P7.

64 Mariselvam R, Ranjitsingh AJA, Usha Raja Nanthini A, Kalirajan K, Padmalatha C, MosaeSelvakumar P. Green synthesis of silver nanoparticles from the extract of the inflorescence of Cocos nucifera (Family: Arecaceae) forenhanced antibacterial activity. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy. 2014;129:53741

65.Borase HP, Patil CD, Salunkhe RB, Suryawanshi RK, Kim BS, Bapat VA, et al. Bio-Functionalized Silver Nanoparticles: a Novel Colorimetric Probe for Cysteine Detection. Applied Biochemistry and Biotechnology. 2015;175(7):3479-93.

66.Ashok kumar S, Ravi S, Kathiravan V, Velmurugan S. RETRACTED: Synthesis of silver nanoparticles using
A. indicumleaf extract and their antibacterial activity. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy. 2015;134:34-9.

67.Gallucci MN, Fraire JC, Ferreyra Maillard APV, Páez PL, Aiassa Martínez IM, Pannunzio Miner EV, et al. Silver nanoparticles from leafy green extract of Belgian endive (Cichorium intybus L. var. sativus): Biosynthesis, characterization, and antibacterial activity. Materials Letters. 2017;197:98-101.

68.Ahmad N, Sharma S. Green synthesis of silver nanoparticles using extracts of Ananas comosus. Green and Sustainable Chemistry. 2012;2(04):141

69.Pedrycz W, Bortolan G, Degani R. Classification of electrocardiographic signals: a fuzzy pattern matching approach. Artificial Intelligence in Medicine. 1991;3(4):211-26.

70. Shukla VK et al (2012) Green synthesis of nanosilver as a sensor for detection of hydrogen peroxide in water. J Hazard Mater 213:161–166

71. Armendariz V et al (2004) Size controlled gold nanoparticle formation by Avena sativa biomass: use of plants in nanobiotechnology. J Nanopart Res 6(4):377–382
72. Shankar SS, Ahmad A, Sastry M (2003) Geranium leaf assisted biosynthesis of silver nanoparticles. Biotechnol Prog 19(6):1627–1631.

73 Thakor AS, Jokerst J, Zavaleta C, Massoud TF, Gambhir SS (2011) Gold nanoparticles: A revival in pecious metal administration to patients. Nano Lett 11: 4029- 4036.
74. Chandran K, Song S, Yun S (2014) Effect of size and shape controlled biogenic synthesis of gold nanoparticles and their mode of interactions against food borne bacterial pathogens

75.Wang Y, He X, Wang K, Zhang X, Tan W (2009) BarbatedSkullcup herb extract-mediated biosynthesis of gold nanoparticles and its primary application in electrochemistry. Colloids Surfaces B Biointerfaces 73: 75-79. 5.

76.Raghunandan D, Bedre MD, Basavaraja S, Sawle B, Manjunath SY, et al. (2010) Rapid biosynthesis of irregular shaped gold nanoparticles from macerated aqueous extracellular dried clove buds (Syzygiumaromaticum) solution. Colloids Surfaces B Biointerfaces 79: 235-240.

77.Shankar SS, Ahmad A, Pasricha R, Sastry M. Bioreduction of chloroau- rate ions by geranium leaves and its endophytic fungus yields gold nanoparticles of different shapes. J Mater Chem. 2003;13:1822. https :// doi.org/10.1039/b3038 08b.

78.Ghodake GS, Deshpande NG, Lee YP, Jin ES. Pear fruit extract-assisted room-temperature biosynthesis of gold nanoplates. Colloids Surf B Biointerfaces. 2010;75:584–9. https ://doi.org/10.1016/j.colsu rfb.2009.09.040.

79.Nestor, A.R.V., Mendieta, V.S., López, M.A.C., Espinosa, R.M.G., López, M.A.C. and Alatorre, J.A.A. (2008) Solventless Synthesis and Optical Properties of Au and Ag Nanoparticles Using Camellia sinensis Extract. Materials Letters, 62, 3103-3105. http://dx.doi.org/10.1016/j.matlet.2008.01.138

80.Ratul Kumar Das, BibhutiBhusanBorthakur ,Utpal Bora., Green synthesis of gold nanoparticles using ethanolic leaf extract of Centella asiatica., Materials Letters 64 (2010) 1445–1447

81.Shankar SS, Rai A, Ahmad A, Sastry M. Controlling the optical properties of lemongrass extract synthesized gold nanotriangles and poten- tial application in infrared-absorbing optical coatings. Chem Mater. 2005;17:566–72. https ://doi.org/10.1021/cm048 292g.

82.Gardea-Torresdey JL, Gomez E, Peralta-Videa JR, et al. Alfalfa sprouts: a natural source for the synthesis of silver nanoparticles. Langmuir. 2003. https ://doi.org/10.1021/la020 835i.
83.Gardea-Torresdey JL, Parsons JG, Gomez E, et al. Formation and growth of au nanoparticles inside live alfalfaplants. Nano Lett.2002;2:397–401 https ://doi.org/10.1021/nl015 673+.

84.Gardea-Torresdey JL, Tiemann KJ, Gamez G, et al. Gold nanoparticles obtained by bio-precipitation from gold(III) solutions. J Nanoparticle Res. 1999;1:397–404. https ://doi.org/10.1023/A:10100 08915 465.

85.Ankamwar B, Chaudhary M, Sastry M. Gold nanotriangles biologically synthesized using tamarind leaf extract and potential application in vapor sensing. Synth React Inorg Metal Org Nano-Metal Chem. 2005;35:19–26. https ://doi.org/10.1081/SIM-20004 7527.

86.Narayanan KB, Sakthivel N. Coriander leaf mediated biosynthesis of gold nanoparticles. Mater Lett. 2008;62:4588–90. https ://doi.org/10.1016/j. matle t.2008.08.044

87.Armendariz V, Herrera I, Peralta-Videa JR, et al. Size controlled gold nanoparticle formation by Avena sativa biomass: use of plants in nanobiotechnology. J Nanoparticle Res. 2004;6:377–82. https ://doi. org/10.1007/s1105 1-004-0741-4.

88 Jiale H, Qingbiao L, Daohua S, Yinghua L, Yuanbo S, Xin Y, et al. Biosynthesis of silver and gold nanoparticles by novel sundried Cinnamomum camphora leaf. Nanotechnology. 2007;18(10):105104

89 Rajan A, MeenaKumari M, Philip D. Shape tailored green synthesis and catalytic properties of gold nanocrystals. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy. 2014;118:793-9.

90.Paul K, Bag BG, Samanta K. Green coconut (Cocos nucifera Linn) shell extract mediated size controlled green synthesis of polyshaped gold nanoparticles and its application in catalysis. Applied Nanoscience. 2014;4(6):769-75.

91.Song JY, Jang H-K, Kim BS. Biological synthesis of gold nanoparticles using Magnolia kobus and Diopyros kaki leaf extracts. Process Biochemistry. 2009;44(10):1133-8

92.Philip D. Biosynthesis of Au, Ag and Au–Ag nanoparticles using edible mushroom extract. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy. 2009;73(2):37481.

93.Sheny DS, Mathew J, Philip D. Phytosynthesis of Au, Ag and Au–Ag bimetallic nanoparticles using aqueous extract and dried leaf of Anacardium occidentale.Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy. 2011;79(1):254-62.

94.Philip D, Unni C. Extracellular biosynthesis of gold and silver nanoparticles using Krishna tulsi (Ocimum sanctum) leaf. Physica E: Low-dimensional Systems and Nanostructures. 2011;43(7):1318-22.

95.Dwivedi AD, Gopal K. Biosynthesis of silver and gold nanoparticles using Chenopodium album leaf extract. Colloids and Surfaces A: Physicochemical and Engineering Aspects. 2010;369(1):27-33.

96.Dash SS, Bag BG, Hota P. Lantana camara Linn leaf extract mediated green synthesis of gold nanoparticles and study of its catalytic activity. Applied Nanoscience. 2015;5(3):343-50.

97.Philip D. Rapid green synthesis of spherical gold nanoparticles using Mangifera indica leaf. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy. 2010;77(4):807-10.

98.Dubey SP, Lahtinen M, Särkkä H, Sillanpää M. Bioprospective of Sorbus aucuparia leaf extract in development of silver and gold nanocolloids. Colloids and Surfaces B: Biointerfaces. 2010;80(1):26-33.

99.Sadeghi B, Mohammadzadeh M, Babakhani B. Green synthesis of gold nanoparticles using Stevia rebaudiana leaf extracts: Characterization and their stability. Journal of Photochemistry and Photobiology B: Biology. 2015;148:1016.

100.Ankamwar B. Biosynthesis of gold nanoparticles (green-gold) using leaf extract of Terminalia catappa. J Chem. 2010;7:1334–9. https ://doi. org/10.1155/2010/74512 0.

101.Muthuvel A, Adavallan K, Balamurugan K, Krishnakumar N (2014) and Screening Their Free Radical Scavenging and Antibacterial Properties. Biomed PrevNutrtion,

102.Mohan Kumar K, Mandal BK, Kiran Kumar HA, Maddinedi SB (2013) Green synthesis of size controllable gold nanoparticles. Spectrochim. Acta - Part A Mol BiomolSpectrosc 116: 539-545.

103.Islam NU, Jalil K, Shahid M, Muhammad N, Rauf A (2015) Pistacia integerrima gall extract mediated green synthesis of gold nanoparticles and their biological activities. Arab J Chem.
104.Yoki Yulizar,TresyeUtari, HaritsAtikaAriyanta,andDighaMaulina; Green Method for Synthesis of Gold Nanoparticles

105.Using Polysciasscutellaria Leaf Extract under UV Light and Their Catalytic Activity to Reduce Methylene Blue; Journal of Nanomaterials Volume 2017, 105.Sadeghi B (2015) Zizyphusmauritiana extract-mediated green and rapid synthesis of gold nanoparticles and its antibacterial activity. J Nanostructure Chem 5: 265-273.

106.Annamalai A, Christina VLP, Sudha D, Kalpana M, Lakshmi PTV (2013) Green synthesis, characterization and antimicrobial activity of Au NPs using Euphorbia hirta L. leaf extract. Colloids Surfaces B Biointerfaces 108: 60-65.

107.Islam NU, Jalil K, Shahid M, Muhammad N, Rauf A (2015) Pistacia integerrima gall extract mediated green synthesis of gold nanoparticles and their biological activities. Arab J Chem

108 .S. Rajeshkumar, Synthesis of silver nanoparticles using fresh bark of Pongamia pinnata and characterization of its antibacterial activity against gram positive and gramnegative pathogens, Resour. Technol 2 (2016) 30–35, doi: 10.1016/j.
reffit.2016.06.003

109. SiavashIravani, "Green synthesis of metal nanoparticles victimization plants" ,Green , 2011 pubs.rsc.org

110 Iravani, S., 2011. Green synthesis of metal nanoparticles using plants. Green Chem. 13,2638– 2650.

111. Kharissova, O.V., Dias, H.V.R., Kharisov, B.I., Perez, B.O., Perez, V.M.J., 2013. The greener synthesis of nanoparticles. Trends Biotechnol. 31, 240–248.

112. S. Ahmed, M. Ahmad, B.L. Swami, S. IkramA review on plants extract mediated synthesis of silver nanoparticles for antimicrobial applications: a green expertise J. Adv. Res., 7 (1) (2016), pp. 17-28

113. Fazlzadeh, M., Khosravi, R., Zarei, A., 2017. Green synthesis of zinc oxide nanoparticles using Peganum harmala seed extract, and loaded on Peganum harmala seed powdered activated carbon as new adsorbent for removal of Cr(VI) from aqueous solution. Ecol. Eng. 103, 180–190.

114. Matinise, N., Fuku, X.G., Kaviyarasu, K., Mayedwa, N., Maaza, M., 2017. ZnO nanoparticles via Moringa oleifera green synthesis: physical properties &mechanismof formation. Appl. Surf. Sci. 406, 339–347.

115..Nava, O.J., Luque, P.A., Gomez-Gutierrez, C.M., Vilchis-Nestor, A.R., Castro-Beltran, A.,Mota- Gonzalez, M.L., Olivas, A., 2017a. Influence of Camellia sinensis extract on Zinc Oxide nanoparticle green synthesis. J. Mol. Struct. 1134, 121–125.

116. Sangeetha, G., Rajeshwari, S., Venckatesh, R., 2011. Green synthesis of zinc oxide nanoparticles by aloe barbadensis miller leaf extract : structure and optical properties. Mater. Res. Bull. 46, 2560–2566.

117.D. Nath, P. Banerjee, Environ. Toxicol. Pharmacol, 2013; 36: 997–1014.

118.C. M. Noorjahan, S. K. Jasmine Shahina, T. Deepika, Summera Rafiq. Green Synthesis and Characterization of Zinc Oxide Nanoparticles from Neem (Azadirachta indicia).International Journal of Scientific Engineering and Technology Research, August-2015;04(30): 5751- 5753.

119. M.N. Alam, S. Das, S. Batuta, N. Roy, A. Chatterjee, D. Mandal, N.A. Begum, ACS Sustain. Chem. Eng., 2014; 2: 652–664

120. Singh, A.K., Pal, P., Gupta, Vinay, Yadav, T.P., Gupta, Vishu, Singh, S.P., 2018. Green synthesis, characterization and antimicrobial activity of zinc oxide quantum dots using Eclipta alba. Mater. Chem. Phys. 203, 40–48.

121. Ain Samat, N., Md Nor, R., 2013. Sol-gel synthesis of zinc oxide nanoparticles using Citrus aurantifolia extracts. Ceram. Int. 39, S545–S548. https://doi.org/10.1016/j.ceramint.2012.10.132.

122. Matinise, N., Fuku, X.G., Kaviyarasu, K., Mayedwa, N., Maaza, M., 2017. ZnO nanoparticles via Moringa oleifera green synthesis: physical properties & mechanism of formation. Appl. Surf. Sci. 406, 339–347. https://doi.org/10.1016/j. apsusc.2017.01.219.
123. D. Nath, P. Banerjee, Environ. Toxicol. Pharmacol, 2013; 36: 997–1014.
124. Sagar Raut, Dr. P. V. Thorat, Rohini Thakre; Green Synthesis of Zinc Oxide (ZnO) Nanoparticles Using OcimumTenuiflorum Leaves; International Journal of Science and Research (IJSR; Volume 4 Issue 5, May 2015
125. Gunalan, S., Sivaraj, R., Rajendran, V., 2012. Green synthesized ZnO nanoparticles against bacterial and fungal pathogens. Prog. Nat. Sci. Mater. Int. 22, 693–700. https://doi.org/10.1016/j.pnsc.2012.11.015.
126. Sutradhar, P., Saha, M., 2017. Green synthesis of zinc oxide nanoparticles using tomato (Lycopersicon esculentum) extract and its photovoltaic application. J. Exp. Nanosci. 11, 314–327. https://doi.org/10.1080/17458080.2015.1059504.
127.Fazlzadeh, M., Khosravi, R., Zarei, A., 2017. Green synthesis of zinc oxide nanoparticles using Peganum harmala seed extract, and loaded on Peganumharmala seed powdered activated carbon as new adsorbent for removal of Cr(VI) from aqueous solution. Ecol. Eng. 103, 180–190. https://doi.org/10.1016/j.ecoleng.2017.02.052
128. Khatami, M., Alijani, H.Q., Heli, H., Sharifi, I., 2018a. Rectangular shaped zinc oxide nanoparticles: green synthesis by Stevia and its biomedical efficiency. Ceram. Int. 44, 15596–15602.https://doi.org/10.1016/j.ceramint.2018.05.224.

129.Bala, N., Saha, S., Chakraborty, M., Maiti, M., Das, S., Basu, R., Nandy, P., 2015. Green synthesis of zinc oxide nanoparticles using Hibiscus subdariffa leaf extract: effect of temperature on synthesis, anti-bacterial activity and anti- diabetic activity. RSC Adv. 5, 4993–5003.

130.Khan, M.M., Saadah, N.H., Khan, M.E., Harunsani, M.H., Tan, A.L., Cho, M.H., 2019. Potentials of Costuswoodsonii leaf extract in producing narrow band gap ZnO nanoparticles. Mater. Sci. Semicond. Process. 91, 194–200. https://doi.org/ 10.1016/j.mssp.2018.11.030.

131Nava, O.J., Luque, P.A., Gomez-Gutierrez, C.M., Vilchis- Nestor, A.R., Castro-Beltran, A., Mota-Gonzalez, M.L., Olivas, A., 2017a. Influence of Camellia sinensis extract on Zinc Oxide nanoparticle green synthesis. J. Mol. Struct.

1134, 121–125.https://doi. org/10.1016/j.molstruc.2016.12.069

132.Sathishkumar, G., Rajkuberan, C., Manikandan, K., Prabukumar, S., DanielJohn, J., Sivaramakrishnan, S., 2018. Facile biosynthesis of antimicrobial zinc oxide (ZnO) nanoflakes using leaf extract of Couroupitaguianensis. Aubl. Mater. Lett. 222, 200.

133.Shahriyari Rad, S., Sani, A.M., Mohseni, S., 2019.
Biosynthesis, characterization and antimicrobial activities of zinc oxide nanoparticles from leaf extract of Mentha pulegium (L.). Microb. Pathog. 131, 239–245. https://doi.org/10.1016/j. micpath.2018.01.003.

134 N. Abirami, R. Arulmozhi, Siddharth A. G. S. Plant Mediated Synthesis, Characterization of Zinc Oxide Nanoparticles using Simarouba glauca and its Antibacterial Activities. Research J.

Pharm. and Tech. 2020; 13(4):1817- 1822. doi: 10.5958/0974-360X.2020.00327.3

135.S. Ambika and M. Sundrarajan, "Antibacterial behaviour of Vitex negundo extract assisted ZnO nanoparticles against pathogenic bacteria," Journal of Photochemistry and Photobiology B: Biology, vol. 146, pp. 52–57, 2015.View at: Publisher Site | Google Scholar

136.M. Ramesh, M. Anbuvannan, and G. Viruthagiri, "Green synthesis of ZnO nanoparticles using Solanum nigrum leaf extract and their antibacterial activity," Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, vol. 136, pp. 864–870, 2015

137.D. Sharma, M. I. Sabela, S. Kanchi et al., "Biosynthesis of ZnO nanoparticles using Jacaranda mimosifolia flowers extract: Synergistic antibacterial activity and molecular simulated facet specific adsorption studies," Journal of Photochemistry and Photobiology B: Biology, vol. 162, pp. 199–207, 2016.

138.P. Rajiv, S. Rajeshwari, and R. Venckatesh, "Bio- fabrication of zinc oxide nanoparticles using leaf extract of Parthenium hysterophorus L. and its size-dependent antifungalactivityagainst plant fungal pathogens,"Spectrochimica Acta PartA: Molecular and Biomolecular Spectroscopy, vol. 112, pp. 384–387, 2013.

139.M.Anbuvannan,M.Ramesh,G.Viruthagiri,N.Shanmugam, and N. Kannadasan, "Anisochilus carnosus leaf extract mediated synthesis of zinc oxide nanoparticles for antibacterial and photocatalytic activities," Materials Science in Semiconductor Processing, vol. 39, pp. 621–628, 2015a.

140.M.Stan,A.Popa,D.Toloman,A.Dehelean,I.Lung,andG.Katona,"Enhancedphotocatalyticdegradationproperties of zinc oxide nanoparticles synthesized by using plant extracts," Materials Science in Semiconductor Processing, vol. 39, pp. 23–29, 2015.

141.S.Ashokkumar, S.Ravi, V.Kathiravan, S. Velmurugan, Synthesis of silver nanoparticlesusingA.indium leaf extract and their

142.H.RajaNaika, K. Lingaraju, K.Manjunath, D. Kumar, G. Nagaraju, D. Suresh, H.Nagabhushana, Green synthesis of CuOnanoparticles,using Gloriosa superba L. Extract andtheir antibacterial activity. Journal of Taibah University for Science. vol.9, pp.7-12, 2015.

143.G. Borkow, R.C. Zatcoff, J.Gabbay, Reducing the risk of skin pathologies in diabetics by using copper impregnated socks. Med.Hypotheses vol.73, pp. 883-886, 2009.

144.V. Vellora, T.Padil and M. Cerník, Green synthesis of copper oxide nanoparticles using gum karaya as a biotemplate and their antibacterial application. Int J Nanomedicine. vol. 8, pp.889–898, 2013.

145.J. Huang, Q. Li, D. Sun, Y. Lu, Y. Su, X. Yang, H. Wang, Y. Wang, W.Shao, N.He, Biosynthesis of silver and gold nanoparticles by novel sundried Cinnamomum camphora leaf. Nanotechnology. vol.18, No .10, pp.105104- 105115, 2007

146. Amit KumarMittalaUttamChandBanerjeeaSynthesis of metallic nanoparticles using plant extracts Biotechnology AdvancesVolume 31, Issue 2, March–April 2013, Pages 346- 356

147 .Reddy KR. Green synthesis, morphological and optical studies of CuO nanoparticles. J Mol Struct. 2017;1150:553–557. [Crossref], [Web of Science ®], [Google Scholar]

148.Li J, Sun F, Gu K, et al. Preparation of spindly CuO micro-particles for photodegradation of dye pollutants under a halogen tungsten lamp. Appl Catal A General. 2011;406:51–58.

149.Ghidan AY, Al-Antary TM, Awwad AM. Green synthesis of copper oxide nanoparticles using Punica granatum peels extract: effect on green peach Aphid. Environ Nanotechnol Monitor Manag. 2016;6:95–98. [Crossref], [Google Scholar]

150.Morteza Yadi, Ebrahim Mostafavi, Bahram Saleh, et al.Current developments in green synthesis of metallic nanoparticles using plant extracts: a review.Artificial Cells, Nanomedicine, and Biotechnology An International JournalVolume 46, 2018 - Issue sup3 https://doi.org/10.1080/21691401.2018.1492931

151. Gunalan, S., Sivaraj, R. &Venckatesh, R. Aloe barbadensis Miller mediated green synthesis of mono- disperse copper oxide nanoparticles: Optical properties. Spectrochim. ACTA PART A Mol. Biomol. Spectrosc. 97, 1140–1144 (2012).

152.Rajesh, K. M., Ajitha, B., Kumar, Y. A., Suneetha, Y. & Reddy, P. S. Assisted green synthesis of copper nanoparticles using Syzygiumaromaticum bud extract : Physical , optical and antimicrobial properties. Opt. - Int. J.Light Electron Opt. 154, 593–600 (2018).

153.Reddy, K. R. Green synthesis , morphological and optical studies of CuO nanoparticles. J. Mol. Struct. 1150, 553–557 (2017)

154.Nasrollahzadeh, M., Sajadi, S. M. &Khalaj, M.Green synthesis of copper nanoparticles using aqueous extract of the leaves of Euphorbia esula L and their catalytic activity for ligand-free Ullmann-. RSC Adv. 4, 47313– 47318 (2014).

155. Kaur, P., Thakur, R. & Chaudhury, A. Green Chemistry Letters and Reviews Biogenesis of copper nanoparticles using peel extract of Punica granatum and their antimicrobial activity against opportunistic pathogens. Green Chem. Lett. Rev. 9, 33–38 (2016).

156 He W, Liu X, Kienzle A, M€uller WEG, Feng Q. 2016. In vitro uptake of silver nanoparticles and their toxicity in human mesenchymal stem cells derived frombone marrow. J NanosciNanotechnol. 16:219–228

157. Andara M, Agarwal A, Scholvin D, Gerhardt RA, Doraiswamy A, Jin C, et al. 2006. Hemocompatibility of diamond like carbon–metal composite thin films. Diam Relat Mater 15:1941– 1948.

158. Akhavan A, Sodagar A, Mojtahedzadeh F, Sodagar K. 2013. Investigating the effect of incorporating nanosilver/nanohydroxyapatite particles on the shear bond strength of orthodontic adhesives. Acta Odontol Scand. 71:1038–1042.

159.Chaloupka K, Malam Y, Seifalian AM. 2010. Nanosilver as a new generation of nanoproduct in biomedical applications. Trends Biotechnol. 28:580– 588.

160.Lu L, Sun R, Chen R, Hui C-K, Ho C-M, Luk JM, et al. 2008. Silver nanoparticles inhibit hepatitis B virus replication. AntivirTher. 13:253. Lu S, Gao W, Gu HY. 2008. Construction, application and biosafety of silver nanocrystalline chitosan wound dressing. Burns. 34:623–628

161.Roe D, Karandikar B, Bonn-Savage N, Gibbins B, Roullet J-B. 2008. Antimicrobial surface functionalization of plastic catheters by silver nanoparticles. J Antimicrob Chemother. 61:869–876.

162.Hussain SM, Hess K, Gearhart J, Geiss K, Schlager J. 2006. The interaction of manganese nanoparticles with PC-12 cells induces dopamine depletion. Toxicol Sci. 92:456–463.

163.Chou CW, Hsu SH, Wang PH. 2008.Biostability and biocompatibility of poly(ether)urethane containing gold or silver nanoparticles in a porcine model. J Biomed Mater Res A. 84:785–794.

164.Kotthaus S, Gunther BH, Hang R, Sch€aferH. 1997. Study of isotropicallyconductive bondings filled with aggregates of nano-sited Ag-particles. Comp PackagManuf Technol Part A IEEE Trans. 20:15–20.

165.Hau SK, Yip H-L, Leong K, Jen AK-Y. 2009.Spraycoating of silver nanoparticle electrodes for inverted polymer solar cells. Org Electron. 10:719– 723.

166.Fukuda K, Sekine T, Kobayashi Y, Takeda Y, Shimizu M, Yamashita N, et al. 2012. Organic integrated circuits using room-temperature sintered silver nanoparticles as printed electrodes. Org Electron. 13:3296–3301

167.Yoon KY, Byeon JH, Park CW, Hwang J. 2008. Antimicrobial effect of silver particles on bacterial contamination of activated carbon fibers. Environ Sci Technol. 42:1251–1255.

168. Zhang H. Application of Silver Nanoparticles in Drinking Water Purification. 2013, University of Rhode Island

169.Kumar A, Vemula PK, Ajayan PM, John G. 2008. Silver-nanoparticleembedded antimicrobial paints based on vegetable oil. Nat Mater. 7:236–241.

170.Benn TM, Westerhoff P. 2008. Nanoparticle silver released into water from commercially available sock fabrics. Environ Sci Technol. 42:4133–4139.

171.Ramos K, Ramos L, Camara C, Gomez-Gomez

M. 2014. Characterization and quantification of silver nanoparticles in nutraceuticals and beverages by asymmetric flow field flow fractionation coupled with inductively coupled plasma mass spectrometry. J Chromatogram A. 1371:227–236.

172.Duncan TV. 2011. Applications of nanotechnology in food packaging and food safety: barrier materials, antimicrobials and sensors. J Colloid Interface Sci. 363:1–24
.
173.Morones JR, Elechiguerra JL, Camacho A, Holt K, Kouri JB, Ram ırez JT, et al. 2005. The bactericidal effect of silver nanoparticles. Nanotechnology. 16:2346
174.http://www.rsc.org/chemistryworld/News/2006/April
/11040601.asp)

175.Das S., et al. "Biosynthesized silver nanoparticles by ethanolic extracts of Phytolacca decandra, Gelsemium sempervirens, Hydrastis canadensis and Thuja occidentalis induce differential cytotoxicity through G2/M arrest in A375 cells". Colloids and Surfaces B: Biointerfaces 101 (2013): 325–336.

176.Alt V., et al. "An in vitro the antibacterial properties and cytotoxicity of nanoparticle silver bone cement". Biomaterials 25(2004):4383-4391

177.Russier-Antoine I, Huang J, Benichou E, Bachelier G, Jonin C, Brevet PF. 2008. Hyper Rayleigh scattering of protein-mediated gold nanoparticles aggregates. Chem Phys Lett. 450:345–349

178.Huang X, Neretina S, El-Sayed MA. 2009. Gold nanorods: fromsynthesis and properties to biological and biomedical applications. Adv Mater. 21:4880– 4910

179.Doubrovsky VA, Yanina IY, Tuchin VV. 2010. I nhomogeneity of photo-induced fat cell lipolysis. In: Tuchin VV, Genina EA, Eds. Sartov Fall Meeting Sep 1, 2010. Location:United Kingdom. International Society for Optics and Photonics.

180.Wang G, Stender AS, Sun W, Fang N. 2010. Optical imaging of non- fluorescent nanoparticle probes in live cells. Analyst. 135: 215–221.

181.J.Vaishnav,V.Subha,S.Kirubanandan,M.Arulmoz hi,andS.Renganathan,"Greensynthesis of zinc oxide nanoparticles by Celosia argentea and its characterization," Journal of Optoelectronic and Biomedical Materials, vol. 9, pp. 59–71, 2017.

182.S.Sudhagar,S.Sathya,K.Pandian,andB.S.Lakshmi, Targeting and sensing cancer cells with ZnO Nano probes in vitro," Biotechnology Letters, vol. 33, no. 9, pp. 1891–1896, 2011

183.P. Zhang and W. Liu, "ZnO QD@PMAA-co- PDMAEMA nonviral vector for plasmid DNA delivery and bio imaging," Biomaterials, vol. 31, no. 11, pp. 3087–3094, 2010.

184.Z. Zhao, W. Lei, X. Zhang et al., "ZnO-based amperometric enzyme biosensors," Sensors, vol. 10, no. 2, pp. 1216–1231, 2010.

185.Lazary, A.; Weinberg, I.; Vatine, J.-J.; Jefidoff, A.; Bardenstein, R.; Borkow, G.; Ohana, N. Reduction of healthcare-associated infections in a long-term care brain injury ward by replacing regular linens with biocidal copper oxide impregnated linens. Int. J. Infect. Dis. 2014, 24, 23–29. [CrossRef] [PubMed]

186.Thampi, V.A.; Rajan, S.T.; Anupriya, K.; Subramanian, B. Functionalization of fabrics with PANI/CuO nanoparticles by precipitation route for a nti-bacterial applications. J.Nanopart. Res. 2015,17,1–12. [CrossRef]