

Synthesis and characterization of silver nanoparticles from the extraction of Rosa petals

Submitted in partial fulfillment of the requirements

for the award of

MASTER OF SCIENCE DEGREE

IN PHYSICS

By

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **KISHORE.B(Reg. No.40590012)** who carried out the project entitled **"SYNTHESIS AND CHARACTERIZATION OF SILVER NANOPARTICLES FROM THE EXTRACTION OF ROSA PETALS"** under our supervision from November 2021 to March 2022

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DECLARATION

I **KISHORE. B (Reg. No. 40590012)** hereby declare that the project report entitled **“SYNTHESIS AND CHARACTERIZATION OF SILVER NANOPARTICLES FROM THE EXTRACTION OF ROSA PETALS”** done by me under the guidance of **Dr.S.ANANDHI** (Internal) submitted in partial fulfillment of the requirements for the award of Master of Degree in Physics.

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ABSTRACT

In this study, silver nanoparticles (AgNPs) were synthesized through a green approach by employing Rosa petals (RE) extracts as reducing and stabilizing agents, which were extracted using three different solvents: ethanol (Et), acetone (Ac), and aqueous (Aq). The phase formation was studied using X-ray diffraction (XRD). The morphological analysis was evaluated using a Field Emission Scanning Electron microscope (FESEM), which revealed that the AgNPs are spherical in shape. The phytochemicals of Rosa petals involved in the formation of AgNPs were studied using Fourier Transmission Infrared Spectroscopy (FTIR). These materials have also been studied for antibacterial, anti-diabetic, hemolytic and cell toxicity. The hemolytic studies revealed that all of the samples had concentration-dependent activity, up to 50 µg/mL. RE-Ac-Ag and RE-Et-Ag exhibited non-hemolytic behaviour, whereas RE-Aq-Ag remained non-hemolytic until 100 µg/mL. The anti-diabetic ability of AgNPs was found to be effective, with IC₅₀ values of α-amylase and α-glycosidase being 50, 50, and 75 µg/ml for RE-Et-Ag, RE-Ac-Ag and RE-Aq-Ag, respectively. DPPH assay showed, AgNPs inhibited antioxidants well, with IC₅₀ values of 40 µg/ml for RE-Et-Ag, RE-Ac-Ag and 60 µg/ml for RE-Aq-Ag. The toxicity study revealed that the AgNPs showed size and concentration dependent behavior.

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LIST OF ABBREVIATION

FIB	Fabrication of nanoelectronic beam
UV	Ultra violet
NT	Nanotubes
AFM	Atomic force microscopy
DU	Depleted uranium
CRT	Cathode ray tube
CNF	Cellulose nanofibrils
MFC	Micro fibrillated cellulose
CNC	Cellulose nanocrystals
BC	Bacterial cellulose
MCC	Microcrystalline cellulose
XRD	X ray diffraction
EDS	Energy dispersive x ray spectroscopy
FTIR	Fourier transforms infrared spectroscopy
FESEM	Field emission scanning electron microscopy
AgNP	Silver nanoparticles

AgNO₃	Silver nitrate
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CHAPTER - 1

INTRODUCTION

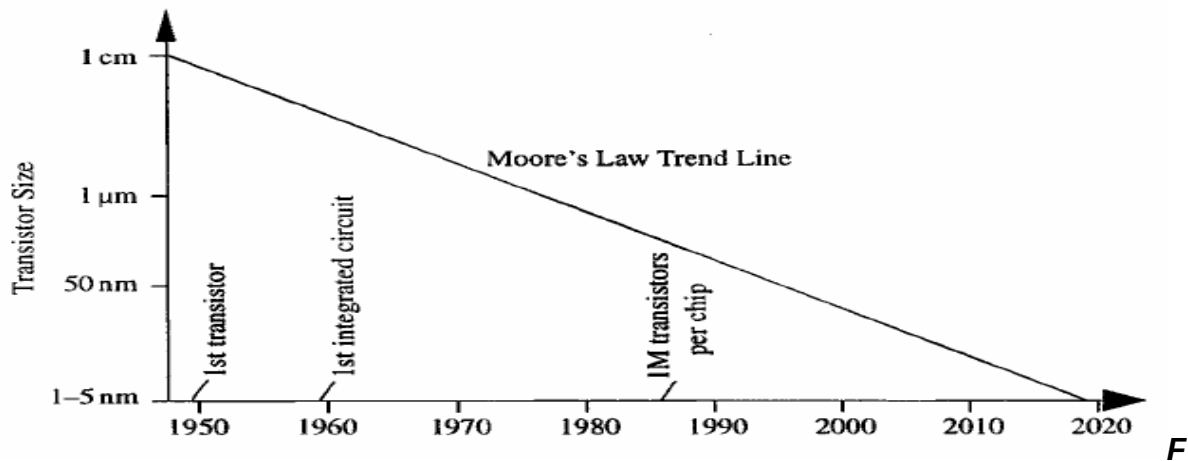
1.1 NANOMATERIALS:

Nanoscience usually offers with synthesis, characterization, exploration, and exploitation of nanostructured substances. These substances are characterized through at the least one measurement withinside the nanometer variety. A nanometer (nm) is one billionth of a meter, or 10^{-9} m. One nanometer is about the period equal to ten hydrogen or five silicon atoms aligned in a line. The processing, shape and homes of substances with grain length withinside the tens to numerous masses of nanometer variety are studies regions of giant hobby over the beyond years. A revolution in substances technological know-how and engineering is taking region as researchers discover methods to sample and signify substances on the nanometer period scale. New substances with extraordinary electrical, optical, magnetic and mechanical homes are hastily being advanced to be used in records technology, bioengineering and strength and environmental applications. On nanoscale, a few bodily and chemical cloth homes can range drastically from the ones of the majority dependent substances of the equal composition; for example, the theoretical energy of nanomaterials may be reached or quantum results may also appear; crystals withinside the nanometer scale have a low melting point (the distinction may be as large as 1000°C) and decreased lattice constants, for the reason that variety of floor atoms or ions turns into a tremendous fraction of the overall variety of atoms or ions and the floor strength performs a tremendous function withinside the thermal stability. Therefore, many cloth homes should now be revisited in mild of the reality that a giant boom in floor-to-quantity ratio is related to the discount in cloth length to the nanoscale, regularly having an outstanding impact on cloth overall performance.

1.2 HISTORY OF NANOMATERIALS:

Historically, essential cloth homes which include elastic modulus had been characterized in bulk specimens the use of macroscopic, and greater currently microscopic, techniques. However, as nanofabrication advances continue, those bulk homes are now not enough to expect overall performance whilst gadgets are fabricated with small vital dimensions. Although nanotechnology is a brand-new location of studies, nanomaterials are recognized to be used for centuries. For example, the Chinese used gold nanoparticles as an inorganic dye to introduce purple color into their ceramic porcelains greater than thousand years ago. Roman glass contained steel nanoparticles, which furnished stunning color. In medieval times, nanoparticles had been used for adornment of cathedral windows. What virtually new approximately nanoscience is the mixture of our capacity to peer and control count number at the nanoscale and our information of atomic scale interactions. Advances withinside the substances processing at the side of the precipitous upward push withinside the sophistication of routine, usually to be had equipment successful for characterization of substances with force, displacement and spatial resolutions as small as Pico Newtons ($PN = 10^{-12}$ N), nanometer ($nm = 10^{-9}$ m) and Angstrom ($A = 10^{-10}$ m), respectively, have furnished exceptional possibilities to probe the shape and mechanical reaction of substances on nanoscale.

In addition, main upgrades in pc help have allowed the simulations of cloth systems and conduct with a diploma of accuracy inconceivable as currently as a decade ago. Although examine on substances withinside the nanometer scale may be traced lower back for centuries, the contemporary fever of nanotechnology is at the least in part pushed through the ever shrinking of gadgets withinside the semiconductor industry. The endured lower in tool dimensions has observed the famous Moore's regulation expected in 1965 and illustrated in Fig. 1.1 The fashion line illustrates the reality that the transistor length has reduced through a component of two every 18 months due to the fact that 1950.



ig. 1.1 “Moore’s Law” plot of transistor size versus year.

There are many nanoscales digital gadgets to be had now: tunneling junctions; gadgets with bad differential electrically configurable switches; carbon nanotube transistor and unmarried molecular transistor; ultrahigh density nanowires lattices and circuits with steel and semiconductor nanowires; etc. Devices have additionally been related collectively to shape circuits able to appearing unmarried features which include basic reminiscence and good judgment function. Computer structure primarily based totally on nanoelectronics (additionally referred to as nano computers) has additionally been intensively studied. Various processing strategies were carried out withinside the fabrication of nanoelectronics which include centered ion beam (FIB), electron beam lithography and imprint lithography. Major obstacles stopping the improvement of such gadgets encompass addressing nanometer-sized objects which include nanoparticles and molecules, molecular vibrations, robustness and the poor electric conductivity. Certainly, nanomaterials play an crucial position now no longer handiest in semiconductor – primarily based totally electronics. Nano-sized substances presently are utilized in several industries, e.g., carbon black debris make rubber tires put on resistant; nanofibers are used for insulation and reinforcement of composites; iron oxide creates the magnetic cloth utilized in disk drives and audio-video tapes; nano-zinc oxides and titania are used as sun blocks for UV rays; etc. Nanoscale debris and nano thin layers of substances are being used, among different things, to make merchandise lighter, more potent or extra conductive. Some of the merchandise available in the marketplace the usage of nanotechnology is: magnetic recording tapes; computer tough drivers; bumpers on cars; solid – kingdom compasses; defensive and glare – reducing coatings for

eyeglasses and windows; car catalytic converters; steel – cutting tools; dental bonding agents; longer – lasting tennis ball; burn and wound dressing; ink; etc. Promising packages of nanotechnology in medication and/or biology have attracted a whole lot of interest and feature end up a quick developing field.

One of the attractive packages in nanomedicine is the introduction of nanoscale gadgets for stepped forward therapy and diagnostics. Such nanoscale gadgets or nanorobots function motors for transport of healing agents, detectors or guardians in opposition to early sickness and possibly restore of metabolic or genetic defects. For packages in medication, the essential venture is “miniaturization”: new gadgets to investigate tissues actually right all the way down to the molecular level, sensors smaller than a molecule permitting to have a take a observe ongoing features, and small Machines that actually flow into inside a human frame pursuing pathogens and neutralizing chemical toxins. Researchers assume to increase new business packages for nanotechnology for the following numerous years. They include: superior drug – turning in systems, including implantable gadgets that robotically administer pills and feel drug levels; medical diagnostic tools, inclusive of cancer – tagger mechanisms and “lab-on-a-chip” diagnostics for physicians; cooling chips or wafer to update compressors in cars, refrigerators, air conditioners and different gadgets, the usage of no chemical compounds or transferring parts; sensors for airborne chemical compounds or different toxins; sun gas cells and transportable energy to offer inexpensive, smooth energy; etc.

1.3 IMPORTANCE OF NANOTECHNOLOGY:

Nanotechnology (NT) is proposed currently to outline the fundamental and engineering sciences that integrates a Chemistry, Physics and Biology of nanostructures with a substances science, electronics, and tactics technology focused on a complete studies of nanostructures, on an improvement of atomistic physical-chemical tactics, self- and automatic-assembling of nanomaterials and workpieces the usage of complicated probe microscopes mixed with different tools, ended in a fabrication and production of nanodevices, nanomachines, ultra-low incorporated circuits, micro opto-electro-mechanical systems, nano biorobots, etc. In truth the NT were arisen in early 80-th, while the scanning tunneling microscopy, the atomic pressure and different probe microscopes had been invented. These have

given the possibility to recognize the principle idea of NT formulated with the aid of using Richard Feynman, namely, to gather artificially the nano workpieces and nanodevices from unmarried atoms and molecules. Huge benefit of Pentium-four over IBM-360 were completed with the aid of using a miniaturizing of incorporated circuits and fabricating of microchips. And this isn't always a limit; the dimensions of character devices can be reduced at least at the orders of magnitudes.

The quantum length outcomes happen themselves in a blue shift of luminescence, withinside the upward thrust of strange low dimensional quantum states, withinside the quantization of electro-conductivity in magnetic field, withinside the oscillation of the superconductivity crucial temperature, magnetoresistance and different bodily characteristics, withinside the technology of hyper sound, etc. Hence, reading the length outcomes in novel nanostructured substances activated with the aid of using distinctive outside fields one can desire for the invention of novel outcomes and phenomena and for the improvement of novel nanotechnology in this base.

1.4 TYPES OF NANOTECHNOLOGY:

Nanotechnology therefore is *the complex interdisciplinary science* including:

1.4.1 Nano chemistry: (nano colloid, sol-gel and quantum chemistry) destined for self-assembling and synthesis of nanoparticles as well as for research of their intrinsic size effects.

1.4.2 Nanophysics: (quantum physics, spintronics, photonics) destined for artificial assembling and fabrication of nanostructures as well as for research of their external size effects.

1.4.3 Nanomaterials science: (nano powder technology, nanoceramics compounds, nanotribology, nano sintering and other nano processes) destined for research, development and production of novel nanostructured architectures, functional nanomaterials and smart nanocomponents with unique properties.

1.4.4 Nanoelectronics, optoelectronics and nanoengineering: destined for development of novel technological processes, nanomotors, nanoactuators, nanodevices, micro-opto electro-mechanical systems (MEMS, MOEMS), ultra-large integrated circuits (ULCI), nanorobots, etc.

1.4.5 Nano bionics: destined for development of novel bio machine complexes, such as nano biochips, nano biorobots, etc.

1.4.6 Nanometrology, nanodevice-building and nano-hand-craft: destined for development of special nanotools, instrumentations, information and computational systems for support of NT itself.

The affiliation of those sciences in nanotechnology displays each their inherent interconnection across the nano objects and the extrude in generation paradigm, namely the nanomaterial, nanodevice or nano system appears to be fabricated by means of the automated synthetic assembling or self-assembling from molecules or clusters in whole, insitu, in area, withinside the unmarried technological technique incorporating them then in microdevices, as a substitute then by means of aggregating of various additives as now. In area of the traditional approaches of thermos-mechanical treatment (the rolling, cutting, welding, soldering, molding, etc.) and of microelectronics approaches (the chemical and bodily vapor depositions, lithography, etc.) the unconventional atomistic nanotechnology approaches (the nanomanipulation, synthetic- and self-assembling, nanolithography, membrane templating synthesis, sol-gel synthesis, molecular-beam epitaxy, etc.) are predicted to will come.

Living in macroworld human come into controllable tunable touch with nanoworld particularly with the aid of a tip of probe microscope, so the touch “tip-floor” is the touch of macroworld with nanoworld. Therefore, the important thing trouble of nowadays nanotechnology is a complete study of atomistic mechanisms of the nanocontact phenomena (adhesion, indentation, friction, wear, etc.) in dependence on a sort of interatomic intermolecular bonds, kind and shape of touch substances, length of tip and nanostructure, cost of load, width of gap, environment, temperature, outside electric and magnetic fields, frequency and depth of electromagnetic waves, and so on. These researches should be expressed in improvement of the strategies for tunable manipulation, characterization, and adhesion of a molecular constructing block onto prescribed area. Such operations at atomic and molecular degree are simply those which emerge as to be essential for nanotechnology. It has to be emphasized that NT has now no longer supposed to update the life micro technologies, however to live in near reference to them to

supplement them withinside the deeper take a look at and superior manage of nanoworld. Atoms, molecules, clusters, fullerenes, supramolecular structures, their crystals, nanotubes, nanowires, nanorods, their arrays and photonic crystal's function NT objectives. Fullerenes and atomic clusters are the smallest zero-dimensional (0D) nanostructures referred to as quantum dots owning the houses inherent for nanomaterial in place of for unmarried atom. Note that for fullerenes it has to suggest now no longer simplest the buckyball C₆₀, however the multitude of every other carbon C_n and noncarbon clusters and metcarbes Me@C_n. Presently some of experimental nanodevices turned into advanced in this base, e.g., the switchers, diodes, transistors, amplifiers, sensors, optical filters, sun cells, magnetooptical recorders, etc.

Nanotubes(NT), nanorods, nanowires, nanofibers happen extra superior and promising houses as being the 1D quantum wires nanoscopic in diameter however microscopic in length. Their specific houses stem from functionality of the hoop and cylindrical kinds of acoustic and electromagnetic waves to propagate that makes them a specific nano laboratory for studies of quantum resonance phenomena. All said above also situation to noncarbon 1D nanowires and nanotubes primarily based totally on boron-nitride, oxides, chalcogenides, dichalcogenides, chalcogenides, and a few different III–V and II–VI compounds owning of the maximum manifold bodily-chemical traits. Reduced two-dimensional 2D heterostructures, nanolayers and nano-disks as being the widely known 2D quantum wells are believed emigrate from micro- to nanoelectronics.

In addition, the 2D arrays of nanowires and nanotubes ordered in 2D forest arrays or 2D crystals appear to be novel and really angle middle of NT. Their specific houses should be decided by means of new standards of electromagnetic waves propagation primarily based totally at the Bragg diffraction regulation in place of on the entire internal reflection. They are the quantum and, withinside the identical time, the macroscopic 2D crystals in which the diverse quantum states and resonance results are predicted. Actually, such resonance states may be identified as the unconventional country of rely, studies of which seems to emerge as the superior path in nanophysics. On this base the waveguides, laser emitting diodes, infrared sensors and different nanodevices have already been advanced. Design and assembling of such synthetic media, look for new uncommon results and

phenomena, in addition to improvement of the updated nanodevices on their base seems to be the maximum promising manner withinside the nearest NT improvement. The instance is the discovery of “left” rely or metamaterials, wherein unconventional inverse refraction regulation, inverse Doppler and inverse Cherenkov results had been observed. In nanomaterials technology the shape-shape engineering will placed withinside the leading edge similarly to the impurity engineering.

Material will become now no longer an uncooked or a pig however it's far forming right away as a nano-workpiece. Note that gain of nanomaterials it was hoping to proclaim itself simply at growing of nanodevices, the digital gnat for instance, in place of withinside the large-scale industry. By peculiarity of the nanoworld is the cancellation of differences among the living and inorganic rely. The change of substance being the indication of lifestyles manifests itself at the supramolecular degree in place of a molecular one. Proteins, membranes, and nucleic acids check with massive herbal nanostructures constructed in end result of self-assembling. The analogy opens a first-rate possibility for nanomaterials and nanodevices fabrication by means of such biomimicry. Artificial increase of pearls internal mussels, in addition to ordering of nonequilibrium defects into 2D nanostructures on a floor of semiconductors beneath the ion bombardment and implantation are the examples.

Principal query is “what are the odd capabilities inherent to in recent times nano generation deliberating that atomic and molecular physics, chemical synthesis technologies, microelectronics, etc., had been existed earlier than NT era?” The novelty includes: – the synthetic manipulating by means of nanoobjects and guide or automated assembling of the nanodevices designed in advance the usage of a “bottom-up” approach; 12 – the planned meddling in approaches mechanisms with the complete manage of a chemical self-assembling at molecular degree; – the invention, layout and manufacturing of nanodevices of sub micrometer length followed by means of their integration into micro-, mezo-, -and macro-systems. Entering into NT it has to be warn of a few illusions and problems. Firstly, lower in debris length is limited from beneath as it does now no longer always end result into development of the houses. For instance, the foremost length of disperse inclusions in oxide ceramics Ca. 10–20 kilocalories turned into proven to exist at which the

foremost mixture of hardness and sturdiness is achieved. Secondly, with debris length lower the approaches of thermal instability and phase transitions had been proven to take area ensuing in nondurability of nano systems. For instance, the famous phrases IBM, NANO, and corals drown on substrate by means of atomic force microscopy (AFM) had been become risky because of speedy floor diffusion of constructing atoms. Since the covalent bonded semiconductors and ceramics ideally seem to be strong and durable, the nanomaterials for NT are idea to be nonmetallic.

Thirdly, a cosmic irradiation and radiation history are successful atoms to knockout from nanostructures main in degradation in their houses and in worsening of nanodevice operation. Fourthly, a thermal noise and vibrations might be tremendous instances influenced the houses and traits of nanodevices. In particular, it limits actuality of probe microscope function, which have to in no way be much less then a half-amplitude of thermal vibrations. Fifthly, even negligible awareness of inherent impurities and irremovable infection permit to ruin the assembling approaches, so a super-high-purity feed reagents and clean-room approaches are required. Concluding, all bodily discoveries in vacuum were already made except in addition discovery of the vacuum itself. Novel discoveries, laws, phenomena, technical decisions, solutions, and innovations might be in all likelihood made simplest in unique designed and assembled synthetic nanostructures to be fabricated by means of destiny substances technology. Materials technology idea is proven in illustrating the inherent interconnection among the composition, shape, houses, generation and applications.

1.5 APPLICATIONS OF NANOMATERIALS:

Nanomaterials can be used in different applications such as in medicine, electronic device, sunscreens, military applications, photovoltaic cells, paints, catalysts, etc. Some of these do not have an effect on the environment, while others have an effect on it.

The Applications of Nanomaterials

- Applications
- Next-Generation Computer Chips

- Kinetic Energy Penetrators with Improved Lethality
- Better Insulation Materials
- Phosphors for High-Definition TV
- Low-Cost Flat-Panel Displays
- Tougher and Harder Cutting Tools
- Elimination of Pollutants

As nanomaterials have exclusive, advantageous physical, chemical, and mechanical properties, they can be applied in a host of applications including, but not limited to, those listed below.

1.5.1 Next-Generation Computer Chips:

The microelectronics area has paid unique interest to miniaturization, which entails lowering the scale of circuits like transistors, capacitors, and resistors. A enormous discount of their length permits microprocessors advanced the usage of those elements, to perform a lot quicker, as a consequence permitting computations at a lot extra speeds. However, there are some of technical barriers to accomplishing those advancements, including the shortage of ultrafine precursors to make those elements, insufficient dissipation of large quantities of warmth generated through those microprocessors due to quicker speeds, terrible imply time to failures (terrible reliability), etc. Nanomaterials assist the enterprise to triumph over those barriers through presenting producers' substances with higher thermal conductivity, nanocrystalline beginning substances, ultra-high-purity substances, and longer-lasting, long-lasting interconnections (connections among distinct elements withinside the microprocessors).

1.5.2 Kinetic Energy Penetrators with Improved Lethality:

The Department of Defense (DoD) has been the usage of depleted uranium (DU) projectiles (penetrators) for its war in opposition to hardened goals and armored automobiles of enemies. But DU has residual radioactivity; therefore, it's far explosive, harmful (carcinogenic), and deadly to employees who use them. However, a number of the important thing motives for the sustained use of DU penetrators are that they've a specific self-sprucing mechanism on effect with a target, in addition to the dearth of the precise non-explosive, non-poisonous opportunity for DU.

Nanocrystalline tungsten heavy alloys may be used for such self-sprucing mechanisms because of their specific deformation characteristics, for example, grain-boundary sliding. Therefore, nanocrystalline tungsten heavy alloys and composites are being assessed to be used as opportunity DU penetrators

1.5.3 Better Insulation Materials:

Nanocrystalline substances synthetic with the aid of using the sol-gel technique deliver upward thrust to foam-like systems recognized as “aerogels.” In spite of being extraordinarily light-weight and porous, those aerogels can keep masses same to a hundred instances their weight. Aerogels are made of non-stop 3-D networks of debris with air (or some other fluid, together with a gas) trapped at their interstices. Since aerogels are porous and consist of air trapped on the interstices, they’re used for insulation in homes, offices, etc. This substantially reduces the cooling and heating bills, accordingly saving energy and lowering the related environmental pollution. They also are being hired as substances for “smart” windows, which darken whilst the solar may be very bright (identical as in changeable lenses in sun shades and prescription spectacles), and lighten whilst the solar isn't shining very brightly.

1.5.4 Phosphors for High-Definition TV:

The decision of a display or tv is problem to the scale of the pixel. These pixels are essentially composed of substances recognized as “phosphors,” which glow whilst struck with the aid of using a circulate of electrons withinside the cathode ray tube (CRT). The decision complements with a discount withinside the pixel length or the phosphors. Nanocrystalline zinc selenide, cadmium sulfide, zinc sulfide, and lead telluride organized via the sol-gel strategies are capability substances for reinforcing the decision of monitors. The use of nanophosphors is supposed to decrease the fee of those shows to make private computer systems and high-definition televisions (HDTVs) low priced for a mean family withinside the United States.

1.5.5 Low-Cost Flat-Panel Displays:

In the laptop (portable) pc industry, the call for flat-panel shows is high. Japan is main on this area, in particular because of its R&D efforts at the substances for those shows. The decision of those show gadgets may be substantially stepped forward with the aid of using synthesizing nanocrystalline phosphors, whilst extensively

bringing down the producing costs. Furthermore, the flat-panel shows synthetic the use of nanomaterials have a long way better comparison and brightness as compared to the conventional ones because of their stepped forward magnetic and electric properties.

1.5.6 Tougher and Harder Cutting Tools:

Cutting equipment fabricated from nanocrystalline substances like carbides of tantalum, tungsten, and titanium, are loads harder, lots extra erosion-resistant and put on-resistant, and closing longer than their traditional (large-grained) equivalents. They additionally permit the producer to system numerous substances lots faster, thereby boosting productiveness and in large part minimizing production costs. Moreover, miniaturizing microelectronic circuits necessitates microdrills (drill bits having diameters lesser than the thickness of a median human hair [100 μm]) with stepped forward side retention and plenty higher put-on resistance. Nanocrystalline carbides are being utilized in those micro drills considering the fact that they're lots harder, stronger, and put on-resistant.

1.5.7 Elimination of Pollutants:

Nanocrystalline substances have very massive grain limitations similar to their grain size. Therefore, they may be very energetic as regards to their physical, chemical, and mechanical properties. Owing to their stepped forward chemical activity, nanomaterials may be hired as catalysts to react with poisonous and noxious gases inclusive of nitrogen oxide and carbon monoxide, in strength era device and vehicle catalytic converters, to keep away from environmental pollutants prompted whilst gas and coal are burnt.

1.5.8 High Energy Density Batteries:

Traditional and rechargeable batteries are utilized in almost all programs that necessitate electric powered power. These programs consist of pc computers, automobiles, toys, electric powered vehicles, private stereos, cordless phones, mobile phones, watches, and next-era electric powered vehicles (NGEV) that lessen environmental pollution. The strength density (garage capacity) of those batteries could be very low, necessitating common recharging. The existence of conventional and rechargeable batteries is likewise low. Nanocrystalline substances produced the use of sol-gel techniques have a foam-like (aerogel) shape which could keep

drastically extra strength than their conventional equivalents. Hence, they're extraordinarily appropriate for separator plates in batteries. Moreover, nickel-metallic hydride (Ni-MH) batteries made from nanocrystalline nickel and metallic hydrides were anticipated to necessitate a good deal lesser recharging and to final drastically longer due to their massive grain boundary (surface) location and advanced chemical, physical, and mechanical properties

1.5.9 High-Power Magnets:

A magnet's strength is measured in terms of saturation magnetization and coercivity values. These values will increase when there is a decrease in the grain size and an increase in the specific surface area (surface area per unit volume of the grains) of the grains. It has been demonstrated that magnets made of nanocrystalline yttrium-samarium-cobalt grains have highly uncommon magnetic properties because of their extremely large surface area.

Common applications for these high-power rare-earth magnets include ultra-sensitive analytical instruments, quieter submarines, land-based power generators, automobile alternators, motors for ships, and magnetic resonance imaging (MRI) in medical diagnostics.

1.5.10 High-Sensitivity Sensors:

Sensors use their sensitivity to detect the variations in different parameters they are programmed to measure. The parameters include chemical activity, thermal conductivity, electrical resistivity, magnetic permeability, and capacitance. All of these parameters depend a lot on the microstructure (grain size) of the materials used in the sensors.

A variation in the sensor's environment is revealed by the sensor material's physical, chemical, or mechanical characteristics, which is leveraged for detection. For example, a carbon monoxide sensor made of zirconium oxide (zirconia) applies its chemical stability to identify whether carbon monoxide is present.

When carbon monoxide is present, the oxygen atoms in zirconium oxide react with the carbon in carbon monoxide to reduce zirconium oxide partially. This reaction activates a modification in the sensor's characteristics, such as capacitance and conductivity (or resistivity).

The rate and the degree of this reaction are significantly increased by a decrease in the grain size. Therefore, sensors made of nanocrystalline materials are highly sensitive to variations in their environment. Common applications for sensors made using nanocrystalline materials are ice detectors on aircraft wings, smoke detectors, automobile engine performance sensors, etc.

1.5.11 Automobiles with Greater Fuel Efficiency:

Existing automobile engines waste substantial amounts of gasoline, thus adding to environmental pollution by burning the fuel incompletely. A traditional spark plug is not made to burn the gasoline totally and efficiently. This problem is amplified by faulty, or worn-out, spark plug electrodes.

Since nanomaterials are harder, stronger, and considerably more erosion-resistant and wear-resistant, they are currently being proposed for use as spark plugs. These electrodes extend the service life of the spark plugs and help burn fuel far more efficiently and fully. A totally new spark plug design known as the “rail plug” is also in the prototype stage.

1.5.12 Bio Nanomaterials:

Nanomaterials are substances having dimensions within the nanometer scale, typically among one to a hundred nm and bio-primarily based totally nanomaterials are nanomaterials originating from natural, plant-primarily based totally substances. Cellulose nanomaterials, or nanocellulose, are possibly the maximum widely recognized bio-primarily based totally nanomaterials, however nano lignin and nano-sized hemicelluloses have additionally received greater hobby recently. Bio-primarily based totally nanomaterials show off special, nano-unique residences as compared to their bulk substances, including excessive unique floor place main to extended reactivity or excessive element ratio presenting them with energy and stiffness. The capacity packages of bio-primarily based totally nanomaterials variety from greater mounted ones, including energy additive in paper and board, to very revolutionary ones, including optical and digital structures. In the subsequent chapters, the reader is brought to extraordinary styles of cellulose micro- and nanomaterials: cellulose nanofibrils (CNF), micro fibrillated cellulose (MFC), cellulose nanocrystals (CNC), bacterial cellulose (BC) and microcrystalline cellulose (MCC) in addition to nano lignin. The principal residences of those grades are mentioned and the hyperlink

among the residences and the capacity packages highlighted. The maximum appropriate characterization strategies for cellulose nanomaterials also are reviewed. The precise residences of cellulose nanomaterials deliver them capacity for sever a package. Various packages are offered, of which the greater superior or capacity ones – paper and board, packaging, composites, membranes and biomedical packages – are mentioned in greater detail. The marketplace for cellulose nanomaterial containing merchandise is brought thru patent panorama evaluation and the economic packages presently available in the marketplace offered primarily based totally at the records given with the aid of using the industry. The manufacturing of cellulose nanomaterials is primarily based totally on many extraordinary technologies, which includes a mixture of mechanical, enzymatic and chemical strategies. Each of those classes is mentioned and issues on commercial manufacturing also are given. In addition, the fame of modern-day commercial manufacturing of cellulose nanomaterials is summarized. A novel post-processing approach for bio-primarily based totally substances, additive manufacturing (3-D printing), is likewise brought. The precise residences of cellulose nanomaterials additionally lead them to behave in a different way toward their organic environment as compared to the identical substances with large dimensions. This may have an impact on their protection, as this relies upon on many, nonetheless poorly understood factors, including their physio-chemical residences, the scale and form of the particles, their aggregation residences, reactivity and unique floor residences amongst others. In addition, their publicity route, whether or not it's far thru breathing route, gastronomic track, pores and skin or eye, has a power on their interactions. The literature posted up to now at the protection of cellulose nanomaterials is reviewed and the maximum crucial findings associated with human fitness and occupational publicity in addition to environmental fitness and publicity are summarized.

Bionanomaterials are synthesized through bio-reduction methods where reducing sugar, proteins, enzymes and phenolic compounds are suggested to purpose the reduction. Synthesis process has been controlled through pH, concentrations (reaction mixture), supply substances nature etc. After synthesis the materials are characterized with UV-seen spectroscopy, X-ray diffraction (XRD) technique, Energy-dispersive X-ray spectroscopy (EDS), X-ray photoelectron spectroscopy (XPS),

Fourier transforms infrared spectroscopy (FTIR), Coupled plasma spectrometry (ICP), Transmission's electron microscope (TEM), Scanning electron microscopy (SEM), Atomic force microscopy (AFM) etc. Though, metal nanoparticles have tremendous applications in the area of catalysis, sensor, optoelectronics, optically functional thin-film coatings, diagnostic biological probes and show devices, bionanoparticles play a significant role in the field of agriculture, biology and medicine. Removal of pollutants has additionally been carrying out the use of nanomaterials. Since the increasing use of bio nanomaterials many fields and in consumer products will increase their launch to the surroundings and any development in nanotechnology would therefore require evaluation of environmental risks associated with those particles.

1.6 TECHNIQUES:

Nanoparticles can be synthesized using three different methods. The following are the details.

(1) Biological approaches

(2) Physical techniques

(3) Chemical techniques

(1) The biological approach is simple and straightforward, usually requiring only one step and is environmentally benign. In this case, we can use microbes as well as various plant parts to make nanomaterials.

The schematic Fig. 1.2 depicts some of the significant advantages of biological approaches of NP synthesis over physical and chemical methods. Green synthesis of NPs, which made use of various biological resources such as plants, fungus, and microorganisms to make NPs. These biological approaches have a number of advantages over chemical and physical methods, including being environmentally benign, preventing pollution and waste creation, efficient synthesis, conserving time and energy, and, most crucially, producing NPs at a low cost. Many recent reviews have presented data on NP biosynthesis, but few have described the impact of

green chemistry on the exact process of biological synthesis of magnetic and metallic NPs, as well as the factors that influence it.



Fig. 1.2 depicts the biological synthesis advantages over physical and chemical methods. Add reference

CHAPTER – 2

LITERATURE SURVEY

According to Das, S (2013)., Understanding and manipulating materials in the size range of 1 to 100 nm, where particles exhibit radically different physico-chemical properties than their bulk counterparts, is what nanotechnology is all about. A number of carefully designed nanoparticles for diagnostic and therapeutic uses have been created in the recent two decades. Nanoparticles enable detection at the molecular level in diagnostic applications. Some fluorescent nanohybrids have the capability of both detecting and killing harmful microorganisms. Using nanoparticles as a contrast enhancement material can considerably improve the specificity and sensitivity of magnetic resonance imaging. They have a lot of potential as a therapeutic agent since they allow for targeted drug delivery and prolonged release, and they also have a lot of potential in tissue engineering. This study focuses on the primary nanoparticle-based diagnostic and therapeutic modalities, given the wide range of applications of nanomaterials in the biomedical sector.

García-Barrasa, J., implies that, silver nanoparticles (Ag NPs) may be easily synthesized in solution using chemical techniques. These metal nanoparticles have a lot of potential in biomedicine as antibacterial, antifungal, and antiviral agents, as well as in wound healing. The ability to precisely manage the size, shape, mono dispersity, and surfaces of nanoparticles is enabled by adjusting the factors involved in these reactions. These nanoparticles are being employed in the development of new biomedical nanomaterials that are hybrid organic-inorganic or inorganic.

Behera, S., states that, a growing variety of items contain nano-silver. Because little is known about the possible hazards of nano-silver, several of the uses have caused worry among governments and the general public. An inventory is created in this study to identify information gaps that must be filled before dangers to both man and the environment can be estimated as accurately as for 'non-nano sized' compounds. The harmful effects of nano-silver are thought to be the result of a combination of unique features of silver nanoparticles and the creation of ions from them. The main focus of future study will be on proving our '0-hypothesis,' which states that the harmful effects of nano-silver are proportionate to the activity of free silver ions released by nanoparticles. Furthermore, whether or not nano-silver particles will

penetrate the body and to what amount must be determined. The results of these tests will decide whether additional toxicity testing is necessary.

Burduşel, A.C., explained that, given that nano silver-based materials have proven to offer fascinating, demanding, and promising features suitable for diverse biomedical applications, silver nanoparticles (AgNPs) have become one of the most examined and explored nanotechnology-derived nanostructures in recent years. The therapeutically improved individualized healthcare practice is attracting a lot of attention among AgNPs' modern biological potential. AgNPs have shown to have real properties and promise in the development of novel antimicrobial agents, drug delivery formulations, detection and diagnosis platforms, biomaterial and medical device coatings, tissue restoration and regeneration materials, complex healthcare condition strategies, and performance-enhanced therapeutic options. Given AgNPs' outstanding medicinal potential, significant research has gone into studying the complicated mechanics of their biological interactions and potential harmful effects. We focused this review on the most recent data on AgNP-based nanostructures' biomedical applications, including aspects related to their potential toxicity, unique physiochemical properties, and bio-functional behaviors, as well as the intrinsic anti-inflammatory, antibacterial, antiviral, and antifungal activities of silver-based nanostructures.

Das, G et al (2019) explains., Green nanotechnology-based techniques based on food waste materials are currently accepted as an environmentally acceptable and cost-effective strategy with a variety of biomedical applications. The outer peel extract of the fruit *Ananas comosus* (AC), which is a food waste material, was used to make AgNPs in this work. UV–visible spectroscopy, X-ray diffraction (XRD), Fourier transform infrared (FT-IR) spectroscopy, scanning electronic microscopy (SEM), and energy-dispersive X-ray spectroscopy (EDX) investigations were used to characterise the samples. The generation of AgNPs has been confirmed using UV–visible spectroscopy (at 485 nm) and the colour shift caused by surface Plasmon resonance. FT-IR was used to examine the functional group in AC outer peel extract that was responsible for the decrease of Ag⁺ ion and stabilisation of AC-AgNPs. SEM and EDX analyses were used to figure out the morphological structures and elemental makeup. The antioxidative, antidiabetic, and cytotoxic capabilities of biosynthesized AC-AgNPs against HepG2 cells, as well as their antibacterial

potential, were investigated in light of the rising application of AgNPs in biomedical aspects. The findings revealed that AC-AgNPs are exceedingly effective, with a high antidiabetic potential at very low concentrations, as well as a dose-dependent increase in cytotoxic activity against HepG2 cancer cells. It also had moderate antibacterial activity and probable antioxidant action against the four foodborne pathogenic bacteria that were examined. Overall, the findings show the efficacy and potential of AC-AgNPs in biomedical sectors such as acute illness therapy and drug formulation for diseases including cancer and diabetes. It can also be used to treat bacterial infections and wound dressings.

The work of Sathiyaseelan, A et al (2020)., states that, This is the first time a Punica granatum leaf extract has been used to make silver nano particles (AgNPs) (PGE). UV–Vis, Fourier transform infrared (FTIR), X-ray powder diffraction (XRD), X-ray photoelectron spectroscopy (XPS), field emission scanning electron microscopy and energy-dispersive spectra (FESEM-EDS), and high-resolution transmission electron microscopy were used to characterise the synthesised AgNPs (HRTEM). The involvement of biological macromolecules of P. granatum leaf extract was revealed by FTIR analysis to be dispersed and involved in the creation and stabilisation of AgNPs. The composition and oxidation state of produced AgNPs were determined using a surface-sensitive XPS method. The AgNPs were found to be crystalline in form, having a spherical shape, according to the analytical data. The surface charge of synthesised AgNPs was highly negative (26.6 mV) as demonstrated by the zeta potential analysis, and particle size distribution ranged from 35 to 60 nm, with an average particle size of roughly 48 nm established by dynamic light scattering (DLS). The antidiabetic potential of PGE-AgNPs was demonstrated by effective inhibition of α -amylase and α -glucosidase (IC₅₀: 65.2 and 53.8 μ g/mL, respectively). PGE-AgNPs had a dose-dependent response against human liver cancer cells (HepG2) (IC₅₀; 70 μ g/mL), showing that they are more effective at killing cancer cells. They also had antioxidant activity in vitro, as measured by ABTS (IC₅₀; 52.2 μ g/mL) and DPPH (IC₅₀; 67.1 μ g/mL) antioxidant activity. Against harmful bacteria, PGE-AgNPs showed high antibacterial action and a potent synergy with conventional medicines. As a result, produced PGE-AgNPs have biological and industrial promise.

Popli, D et al (2018)., This study looked at the effects of antioxidant, anti-diabetic, and anti-acetylcholinesterase (AChE), anti-butyrylcholinesterase (BChE) activities utilising aqueous extract of endophytic fungi, *Cladosporium* species (CsAgNPs) UV–Vis spectrophotometer, Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), and energy dispersive X-ray spectroscopy (EDXS) were used to evaluate *Cladosporium* species-mediated silver nanoparticles (EDX). Carbohydrates, tannin, phenolic glycosides, terpenoids, alkaloids, phenol, and anthraquinones were discovered in the aqueous extract of *Cladosporium* species. The absorbance of AgNPs was uniform at 438 nm. The SEM results show that the produced nanoparticles have a large discrepancy in particle size distribution, as well as a large size, shape, and density. The essential biological components responsible for silver reduction were validated by the FTIR analysis. EDX was used to investigate AgNPs' strong absorption properties. CsAgNPs indicated that NADPH-dependent reductase is involved in the production of AgNPs when it comes to antioxidant action. In vitro antidiabetic activity of α -amylase, α -glucosidase, and dipeptidyl peptidase IV was lowered by AgNPs. In the 3T3L1 cell line, CsAgNPs showed considerable glucose absorption. AgNPs have demonstrated to be highly effective inhibitors of AChE and BChE. To our knowledge, this is the first study to use endophytic fungus, *Cladosporium* species, isolated from healthy *Loranthus micranthus* leaves, to synthesise silver nanoparticles. As a result, in vivo animal research at the molecular level are required to validate our findings in order to develop an antioxidant, anti-diabetic, and anti-cholinesterase agent.

Kong, Y et al (2021)., states that In a recent study, we used cellular models to examine the anti-colorectal cancer properties of silver nanoparticles containing AgNO₃, *Cannabis sativa* L leaf aqueous extract, and *Cannabis sativa*. Silver nanoparticles were also tested for antioxidant, anti-diabetic, and anticholinergic activities. *C. sativa* leaf aqueous extract and AgNO₃ solutions were mixed to make silver nanoparticles. TEM, FT-IR, FE-SEM, and UV–Vis were used to characterise the chemical properties of these nanoparticles. More antioxidant molecules with associated bonds resulted in the ideal situation for silver reduction in silver nanoparticles in the FT-IR assay. The production of silver nanoparticles was visible in the UV–Vis spectrum at 425 nm. The silver nanoparticles were also spherical in TEM and FE-SEM pictures, with an average diameter of 11.5 nm. In a recent study,

the anti-colorectal cancer properties of silver nanop were compared. The anti-colorectal cancer activity of AgNO₃, *C. sativa*, and silver nanoparticles were determined using the MTT test on normal (HUVEC) and colorectal carcinoma (WiDr, SW1417 [SW-1417], DLD-1, LS123, ATRFLOX [Mutatect], and Caco-2) cell lines. In colorectal cancer cell lines, silver nanoparticles showed a very low cell viability. The IC₅₀ of *C. sativa* and AgNPs were 603 and 379 mg/mL, respectively, against the WiDr cell line; 500 and 285 mg/mL, respectively, against the SW1417 [SW-1417] cell line; 649 and 377 mg/mL, respectively, against the DLD-1 cell line; 634 and 350 mg/mL, respectively, against the LS123 cell line; 596 and 241 mg/mL, respectively, against the ATRFLOX [Mutatect] cell line. Against the Caco-2 cell line, the concentrations were 539 and 296 mg/mL, respectively. The ATRFLOX [Mutatect] cell line showed the strongest cytotoxicity response to AgNPs when tested against the above cell lines.

CHAPTER 3

AIM AND SCOPE

- Silver nanoparticles is synthesized through a green approach by employing Rosa petals.
- The phase formation was determined by XRD.
- The surface morphology and elemental analysis were done by SEM.
- The phytochemicals of Rosa petals involved in the formation of Ag nanoparticles were studied using Fourier Transmission Infrared Spectroscopy (FTIR).
- To study antibacterial and anti-diabetic.
- To study hemolytic.
- To accesses cell toxicity.

CHAPTER 4

MATERIALS AND METHODOLOGY

4.1 EXPERIMENTAL WORK

4.1.1 Materials and methods

Silver nitrate (AgNO_3) was purchased from Pallav chemical with analytical grade. Red rose flowers were collected from Gandhi Puram, Chennai. water, acetone, ethanol used were of analytical grade. Whatman filter paper was used.

4.1.2 Preparation of rose extract

Red roses were collected, and the petals were cut into small pieces. The small pieces were weighed to 20 grams, and it was dissolved in ethanol for 2 hours. After that, the extract was filtered, and the solution is used for further synthesis.



Fig 4.2 Acetone as solvent

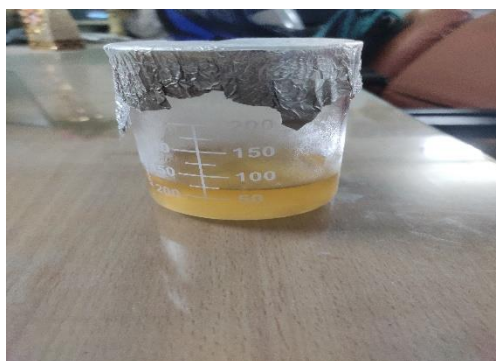


Fig 4.3 Ethanol as solvent



Fig 4.4 Distilled water as solvent

4.2 Preparation of Ag nanoparticles

4.2.1 Ethanol

10 mmol (0.076 g) of silver nitrate (AgNO_3) crystals were dissolved in 100 ml of ethanol. The beaker was closed with aluminium foil, and it was kept under stirring . After the complete dissolution of AgNO_3 crystals, 10 ml of rose extract was added dropwise into Ag solution f(1) . The solution was made to be stirred for 2 hours. Then the solution was kept undisturbed for 24 hours in dark brown. After that, the solution was collected in the centrifugal tube and centrifuged at 5500 rpm. The collected particles were washed with Deionised water, acetone to remove the impurities in the sample. The washed particles were dried at 60°C for 24 hours to remove the water content. The dried particles were grided using mortal and the Ag powder was saved for future use. The other two samples were also prepared by the same method given above and the solvent for dissolving AgNO_3 was changed to acetone and Deionised water.



Fig 4.1 Drop by rose extract

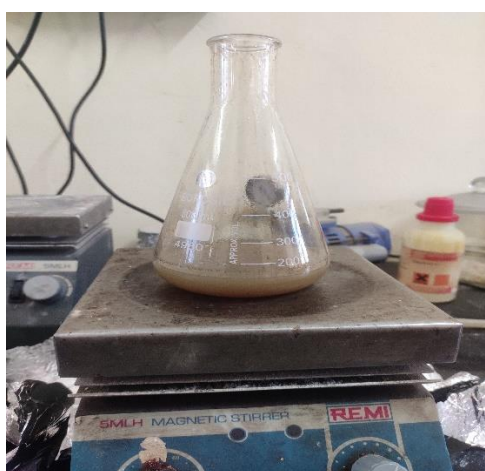


Fig 4.5 Obtained silver nanoparticles(ethanol)

4.2.2 Acetone

10 mmol (0.076 g) of silver nitrate (AgNO_3) crystals were dissolved in 100 ml of acetone. The beaker was closed with aluminium foil, and it was kept under stirring. After the complete dissolution of AgNO_3 crystals, 10 ml of rose extract was added dropwise into Ag solution f(1) . The solution was made to be stirred for 2 hours dark brown. Then the solution was kept undisturbed for 24 hours in stirred. After that, the solution was collected in the centrifugal tube and centrifuged at 5500 rpm. The collected particles were washed with Deionised water, acetone to remove the impurities in the sample. The washed particles were dried at 60°C for 24 hours to remove the water content. The dried particles were grided using mortar and the Ag powder was saved for future use. The other two samples were also prepared by the

same method given above and the solvent for dissolving AgNO_3 was changed to acetone and Deionised water.



Fig 4.6 Obtained silver nanoparticles (Acetone)

4.2.3 Distilled water

10 mmol (0.076 g) of silver nitrate (AgNO_3) crystals were dissolved in 100 ml of distilled water. The beaker was closed with aluminium foil, and it was kept under stirring. After the complete dissolution of AgNO_3 crystals, 10 ml of rose extract was added dropwise into Ag solution f(1). The solution was made to be stirred for 2 hours. Then the solution was kept undisturbed for 24 hours dark brown. After that, the solution was collected in the centrifugal tube and centrifuged at 5500 rpm. The collected particles were washed with Deionised water, acetone to remove the impurities in the sample. The washed particles were dried at 60°C for 24 hours to remove the water content. The dried particles were grided using mortar and the Ag powder was saved for future use. The other two samples were also prepared by the same method given above and the solvent for dissolving AgNO_3 was changed to acetone and Deionised water.



Fig 4.7 Obtained silver nanoparticles(Distilled water)

The obtained powder samples were characterised by XRD, FTIR, SEM, EDAX and particle size analyser to analyse the structural, vibrational, morphological behaviours of the prepared samples.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 X-ray Diffraction

Powder XRD is a small, high-tech instrument. It offers a number of noteworthy features and new attachments, such as a variable temperature assembly and a humidity chamber, which can broaden the scope of its applications by providing data on the effects of temperature and humidity on the nature of materials. When an X-ray passes through a crystal, it diffracts in a pattern that is unique to that crystal's structure. The diffraction pattern is obtained from a powder of the material rather than an individual crystal in powder X-ray diffraction. Because powder diffraction does not require individual crystals, it is generally easier and more convenient than single crystal diffraction. The intensity of a diffraction pattern is plotted versus the detector's angle 2θ . The resulting image is known as a diffractogram. The peak position in a diffraction pattern is determined by the wavelength. Instrumental and experimental conditions can affect absolute intensity (the number of X-rays seen in a given peak).

Diffractometers can be set up to work in both transmission and reflection modes. The one that involves reflection is the most common. When Bragg's Law is satisfied, constructive interference between the incident X-ray beam and the sample produces powerful reflected X-rays.

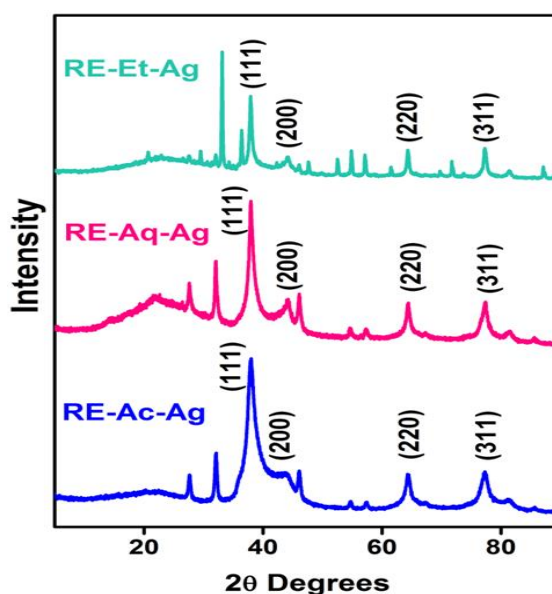


Fig 5.1 The X-ray diffraction (XRD) patterns of the photosynthesized AgNPs

The wavelength of incident X-rays, the incident angle of the beam, and the spacing between the crystal lattice planes of atoms are all described by this law. When the difference in the travel path of the incident X-rays is equal to an integer multiple of the wavelength, constructive interference occurs.

The photosynthesized AgNPs' X-ray diffraction (XRD) patterns are shown in Fig. 5.1 and are found to be remarkably comparable to the normal AgNPs (JCPDS No 89-3722). The reflection peaks are found at 37.9°, 43.9°, 64.3°, and 77.3°, corresponding to the (1 1 1), (2 0 0), (2 2 0), and (3 1 1) planes, suggesting that AgNPs have a face-centered cubic (FCC) structure. Peaks were observed at 27.7 and 31.9, which were due to the deposition of RE phytocompounds.

5.2 FESEM

Electrons are accelerated in a strong electrical field gradient after being liberated from a field emission source. These so-called primary electrons are focused and deflected by electronic lenses within the high vacuum column to generate a narrow scan beam that bombards the item. As a result, secondary electrons are emitted by the object's etch spot. The angle and velocity of these secondary electrons are affected by the object's surface structure. The secondary electrons are caught by a detector, which generates an electronic signal. This signal is amplified and converted into a video scan image that may be viewed on a monitor or a digital image that can be saved and further processed.

The morphological structure of AgNPs is an important indicator when evaluating them because it is linked to their electro-optic and biological capabilities. The spherical like morphology of the AgNPs seen from FESEM images is shown in Fig 5.2 (a-c). The average size of the three samples, RE-ET-Ag, RE-AC-Ag, and RE-Aq-Ag, is 15, 12, and 800nm, respectively, as shown in Fig 5.2 (d-f). The size of silver nanoparticles was clearly influenced by the solvents used in their manufacture. This

could be due to the presence of multiple biomolecules in the extracts, whose functional groups have been altered by the solvent type (i.e., Ethanol, Acetone, and Water), causing particle development to be drastically altered.

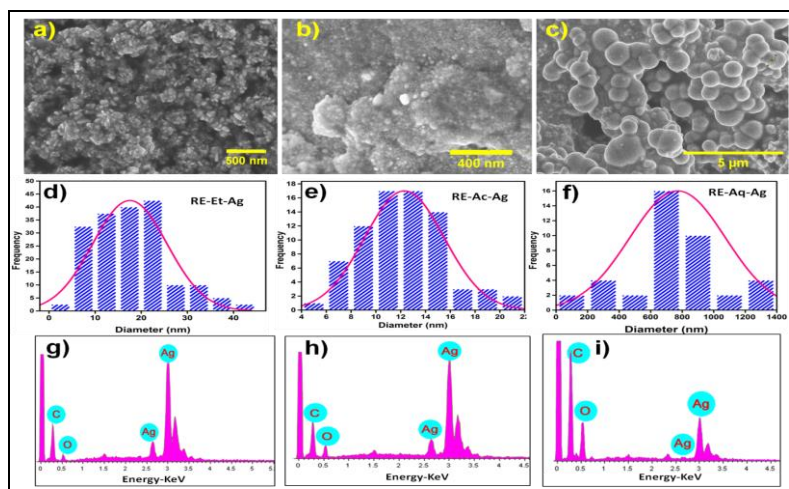


Fig 5.2 (a-c) shows the spherical like morphology of the AgNPs observed from FESEM images. (d-f) represents the average size of the three samples, RE-ET-Ag, RE-AC-Ag, and RE-AQ-Ag. (g-i), the EDX spectrum

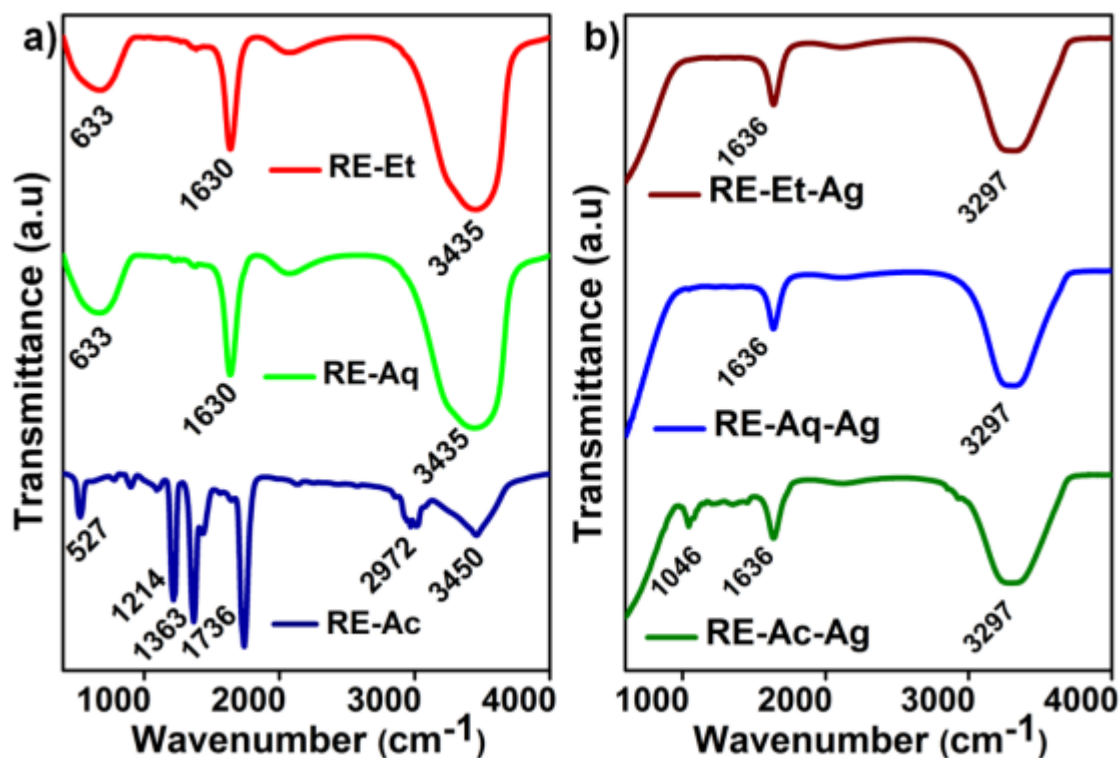
Because the form of the generated AgNPs does not change much with size, the disparities in antibacterial results can only be attributed to changes in nanoparticle size (Swetha CuO and Zhong Lu).

The EDX spectrum of the green generated AgNPs provided semi-quantitative information on the elemental content of the samples, as shown in Figure 5.2(g-i). The rose extracts formed AgNPs successfully, as shown by the EDX spectra.

5.3 FTIR

The molecular vibrations are investigated using infrared spectroscopy. Infrared absorption bands that correspond to the fundamental vibrations of functional groups can be connected with functional groups (Colthup et al. 1975; Griffith and de Haseth 1986). There are $3N-6$ vibrational motions of the molecule atoms, or $3N-6$ basic vibrations or normal modes, for a nonlinear molecule with N atoms. If the dipole moment ~~Footnote2~~ of the molecule changes during the vibration, the usual mode of vibration becomes infrared active (i.e., it absorbs the incident infrared light). As a result, symmetric vibrations are rarely detected in the infrared spectrum. All vibrations that are symmetrical with regard to the centre are infrared inactive when a

molecule has a centre of symmetry. The asymmetric vibrations of all molecules, on the other hand, are detected. This lack of selectivity allows us to investigate the properties of nearly all chemical groups in a single sample, particularly amino acids and water molecules, which are difficult to detect using traditional spectroscopic techniques.



**Fig. 5.3. FTIR spectrum of plant extracts a) RE-Ac, RE-Aq and RE-Et
b) AgNPs RE-Ac-Ag, RE-Aq-Ag and RE-Et-Ag.**

The phytochemicals responsible for the decrease of Ag⁺ ions and the stability of AgNPs were discovered using FTIR studies. The bands at 3435 and 3450 cm⁻¹ in the spectra of RE-Et, RE-Aq, and RE-Ac, shown in fig(5.3) (a), correspond to the O-H stretching vibration, indicating the presence of phenol and alcohol. The aromatic compound C-H stretching created the band at 2972 cm⁻¹ in RE-Ac, but this peak was not identified in RE-Et or RE-Aq. In RE-Et and RE-Aq, C=O stretching vibrations were assigned to the band at 1630 cm⁻¹. In RE-Et and RE-Aq, the band emerged at 633 cm⁻¹, indicating C-C stretching in the alkyl group. C-C stretching, N=O stretching of nitro compounds, and C-N stretching of amines were attributed to RE-Ac peaks at 1736 cm⁻¹, 1363 cm⁻¹, and 1214 cm⁻¹, respectively[19,20]. Fig(5.3) depicts the

presence of 3297, 1636, and 1046 cm^{-1} bands in RE-Et-Ag, RE-Aq-Ag and RE-Ac-Ag (b). As a result, the indicated peaks in the FTIR spectra of AgNPs are impacted in Fig(5.3)b. These FTIR results suggest that biological components are probably involved in AgNP production and stability.

5.4 ANTIMICROBIAL ACTIVITY

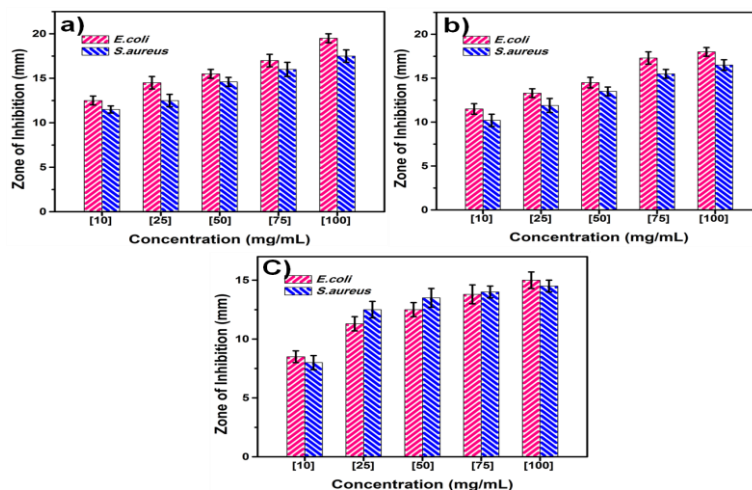


Fig 5.4 a) RE-Ac-Ag b) RE-Et-Ag c) RE-Aq-Ag

The antibacterial activity of AgNPs of various sizes was tested using the well-diffusion method against Gram-negative *E. coli* and Gram-positive *S. aureus* bacterial strains. The antibacterial tests demonstrated that all three materials had potent antibacterial activity against the microorganisms tested; however, the zone of inhibition values obtained were variable and size dependent (Fig. 5.4). The results show that AgNPs made from the solvents Acetone (RE-AC-Ag) and Ethanol (RE-Et-Ag) have a stronger inhibitory effect than AgNPs made from water (RE-Aq-Ag). AgNPs with diameters of 12 nm (RE-Ac-Ag) and 15 nm (RE-Et-Ag) had zone of inhibition values of 25 and 21 mm against *E. coli*, and 23 and 17 mm against *S. aureus*, respectively, according to the current investigation.

The antibacterial activity of bigger AgNPs (RE-Aq-Ag) against *E. coli* and *S. aureus* was determined to be 13 and 11 mm, respectively. This increase in antibacterial activity was attributed to nanoparticle size variation as well as the abundant availability of the functional groups of RE molecules extracted with Acetone and Ethanol, which facilitated the formation of smaller AgNPs and the ability to produce more reactive oxygen species (ROS) to inhibit bacterial growth.

This also showed that the effect of non-aqueous solvents on the surface chemistry of the AgNPs produced improved their antibacterial capabilities by allowing them to easily interact with the bacterium's nuclear content, resulting in the highest nanoparticle-bacteria interaction for efficient killing. Loo et al., for example, described the green synthesis of AgNPs from aqueous extracted Tea leaves. 15nm was discovered to have antibacterial action against *E. coli*. Ahmed et al. reported the synthesis of AgNPs using Azadirachtolide indica aqueous leaf extract in another investigation. Antibacterial activity was reported to be 9 mm against *E. coli* and *S. aureus*. Previous research has also suggested that the antibacterial activity of nanoparticles is size dependent. Because of their greater ability to penetrate germs, smaller particles have proved to have a higher antibacterial effect. SNPs with a smaller surface area have a greater antibacterial effect than those with a larger surface area. When bacterial strains were evaluated, AgNPs were found to be more damaging to *E. coli* than *S. aureus*. Changes in cell structure, diffusion rate, metabolism, and nanoparticle surface interaction with microbes could all be factors.

5.5 HEMOLYSIS

AgNPs were tested at concentrations ranging from 10 to 200 mug/mL for their size-dependent hemolytic activity. According to the findings, the RE-Et-Ag and RE-Ac-Ag samples showed less than 2% hemolysis until 50mug/mL, showing that the materials are completely non-hemolytic. The hemolytic percentage was around 2 to 5% at concentrations ranging from 75 mug/mL to 200 mug/mL, showing that the substance had modest hemolytic effect at these levels. Up to 100 mug/mL, the RE-Aq-Ag sample was non-hemolytic, but at 200 mug/mL, it showed modest hemolytic activity. AgNPs with a lower size had more hemolytic activity than AgNPs with a larger size, according to the findings. Furthermore, the findings indicate that the hemolytic action is concentration dependent.

Many previous research supports our findings that smaller nanoparticles are more damaging than larger particles because their increased surface area allows them to easily breach the membrane and interact forcefully with biomolecules. AgNPs with sizes of 15, 50, and 100 nm showed size-dependent hemolytic activity against fish RBCs, according to Chen et al. Nanoparticles with a diameter of 15 nm were shown

to have a greater ability to generate hemolysis and membrane damage than nanoparticles with diameters of 50 and 100 nm.

According to the researchers, the hemolytic behavior generated by AgNPs is due to the nanoparticle's direct contact with RBCs, which causes oxidative stress, membrane degradation, and, eventually, hemolysis. Overall, the findings suggest that particle size has a considerable influence on AgNP-RBC interactions.

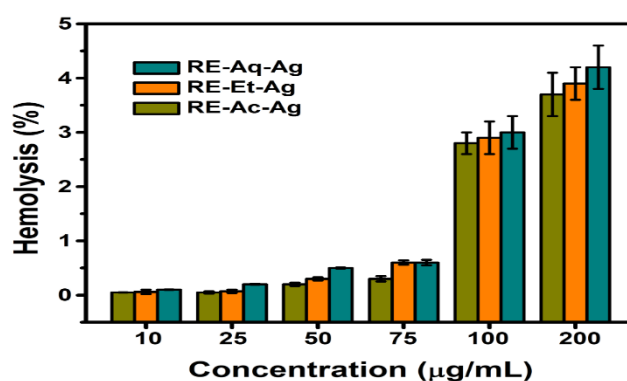


Fig 5.5 shows the hemolytic activity of AgNPs

5.6 CELL VIABILITY

To determine the effect of AgNPs on the proliferation rate of MG63 cell lines, the MTT test was performed. Cell viability was measured by calculating the graph of cell proliferation efficiency after the cells were cultivated for 24 and 48 hours with various sizes of AgNPs at various concentrations. The results showed that cytotoxic activity was size dependent, with RE-Et-Ag and RE-Ac-Ag exhibiting cytotoxic behavior at 125 µg/mL and RE-Aq-Ag exhibiting cytotoxic behavior at 500 µg/mL, respectively. Furthermore, the results show that AgNPs have a concentration-dependent behavior; when the concentration grew from 7.8 to 500 µg/mL, all samples' cell viability decreased. For the samples RE-Et-Ag and RE-Ac-Ag, cell viability decreased after 24 hours of incubation. The cell growth rate in lower concentrations, on the other hand, climbed above the control after 48 hours of incubation. This could be due to AgNPs obtaining ideal conditions after a longer incubation time, resulting in a faster rate of cell growth (Satheesh silver). Soares et

al. used diameters of 10 and 50 nm to investigate the size-dependent cytotoxicity of AgNPs. The data show that 10 nm AgNPs are more dangerous than 50 nm AgNPs. Nanoparticles obstruct lysosomal activity, disrupt membranes, and induce neutrophils to undergo an oxidative burst, according to the findings. The cytotoxicity of nanoparticles against B16 cells of various sizes was explored by Wu et al., who discovered that nanoparticles as tiny as 5 nm were located in the cytoplasm and nucleus, while bigger nanoparticles (20, 50, and 100 nm) were discovered outside the cells. This could be due to the ease with which smaller nanoparticles permeated the cells, whereas larger nanoparticles proved to be extremely difficult to penetrate

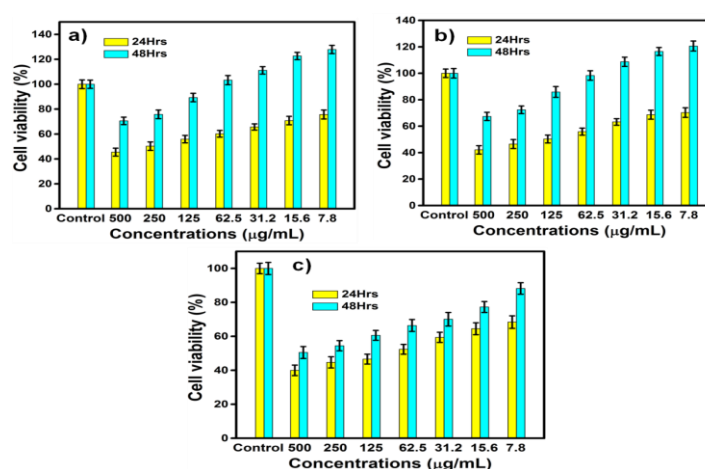


Fig 5.6 a) Ac b) Et c)Aq

5.7 ANTIDIABETIC ACTIVITY

Alpha amylase (-amylase) and alpha glucosidase (-glucosidase) are enzymes that aid in the breakdown of carbohydrates and the absorption of glucose. Inhibiting these two digestive enzymes slows glucose release in the blood and suppresses starch breakdown. AgNPs were incubated with various concentrations of -amylase and -glucosidase (10, 25, 50, 75, and 100 mug/mL) as well as acarbose as a control. AgNPs significantly inhibit -amylase and -glucosidase in a concentration-dependent manner, as shown in Figs. 5.7a and 5.7b. With increasing AgNPs concentrations, the percentage of inhibition increased. RE-Et-Ag, RE-Ac-Ag, and RE-Aq-Ag had IC50 values of 50, 50, and 75 mug/mL for -amylase and -glucosidase, respectively.

As a result, the results demonstrate that AgNPs and acarbose inhibit -amylase and -glucosidase significantly. Balan et al. also found that AgNPs have antidiabetic effect, with IC50 values of 54.56 mug/mL for -amylase and 37.86 mug/mL for -glucosidase,

respectively. Saratalae et al. produced AgNPs from *Punica granatum* leaves and investigated their anti-diabetic effect in another investigation. The IC₅₀ values for α -amylase and α -glucosidase were found to be 65.2 and 53.8 μ g/mL, respectively.

CHAPTER 6

Conclusions

In this work, silver nanoparticles (AgNPs) were synthesized through a green approach by employing Rosa petals and extracted using three different solution ethanol, acetone and aqueous. The phase formation and morphological analysis were done by X-ray diffraction and Field Emission Scanning Electron microscope, confirmed with a spherical shape. With the help of EDAX the weight and atomic percentage were investigated. The phytochemicals of Rosa petals were done by Fourier Transmission Infrared Spectroscopy. Through haemolytic studies it was concluded that all the samples had concentration dependent activity. The anti-diabetic ability of Ag nanoparticles was found to be effective. Further the toxicity study was done and showed size and concentration dependent behaviour. It can be concluded that Re-AcAg, RE-Et-Ag, and RE-Aq-Ag have size-dependent antibacterial properties.