




A Comprehensive Review of Nanomaterials: Types, Synthesis, Characterization, and Applications

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Abstract: Nanotechnology has infiltrated all sectors due to its unique and evident impacts, which give the scientific community numerous breakthroughs in the medical, agricultural, and other domains. Nanomaterials (NMs) have risen to prominence in technological breakthroughs due to their adjustable physical, chemical, and biological characteristics and superior performance over bulk equivalents. NMs are divided into many categories based on size, composition, capping agents, form, and origin. The capacity to forecast NMs' unique features raises the value of each categorization. As the manufacturing of NMs and industrial uses grow, so does their demand. The purpose of this review is to compare synthetic and naturally occurring nanoparticles and nanostructured materials to determine their nanoscale characteristics and to identify particular knowledge gaps related to the environmental application of nanoparticles and nanostructured materials. The paper review includes an overview of NMs' history and classifications and the many nanoparticles and nanostructured materials sources, both natural and manufactured. Furthermore, the many applications for nanoparticles and nanostructured materials.

Keywords: nanotechnology; nanomaterials types; synthesis; characterization; application.

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1. Introduction

Nanotechnology is the process of manipulating the shape and size of structures, electronics, and systems at the nanometer scale, i.e., 1 nm to 100 nm (10^{-9} m) [1,2]. The unit of nanometer takes its prefix nano from the Greek word "nano" which means "very little" [3]. Their small size gives them more significant surface areas than the corresponding bulk forms, higher reactivity, and a tuneable nature of several properties [4-6]. These special properties have stimulated the growth of nanoscience and the application of NPs in a wide range of fields like biomedicine, cosmetics, electronics, analysis food, environmental and remediation, or paints [7-11]. Nanoscale science and engineering allow us to gain a new level of understanding and control matter at the atomic and molecular dimensions [12]. Nanoscale particles have gotten a lot of attention because of their remarkable electrical, optical, and magnetic properties [13]. These NPs have the dimensions that make them suitable candidates for nanoengineering [14,15]. The desire for novel technology applications in data storage, biomedical sciences, and drug delivery has fueled nanoparticle research [16-19]. Core/shell (CS) NPs, polymer-coated NPs, Ag-NPs, Cu-NPs, Au-NPs, Ni-NPs, Pt-NPs, CuO-NPs, ZnO-NPs, Pd-NPs, Si-NPs, FeO-

NPs, ZrO₂-NPs, and TiO₂-NPs are among the metal, metal oxide, and dioxide NPs recently enumerated in various published publications. Each of these NPs has its own set of characteristics and uses [20-23].

2. Capping Agents and Their Types

Capping agents (polymers, organic-ligands, surfactants) are essential in producing metal nanoparticles with precise size and form [24,25]. Their impact on the performance of nanomaterials-based catalysts, on the other hand, is complex and contentious. Indeed, capping agent can operate as both a "poison," reducing active site accessibility, and a "promoter," resulting in higher yields and unexpected selectivity control [26]. These events can be attributed to the formation of metal-ligand interphase, whose specific features are responsible for the catalytic action. As a result, knowing the structure of this interphase is crucial for optimizing the design of customized nanocatalysts [24]. Typical capping agents used in nanoparticles synthesis involve heteroatom functionalized long-chain hydrocarbons. Depending on the nature of the donor atom, they may be categorized as; the broadly classified green capping agents are:

2.1. Biomolecules.

The use of biomolecules to make homogeneous NPs has lately sparked interest due to their non-toxic nature and lack of arduous synthetic techniques [27]. To produce NPs with a unique structure, amino acids serve as effective reducing and capping agents. Maruyama and colleagues used amino acids as capping agents to make Au-NPs with a 4–7 nm size range. They chose L-histidine from a list of 20 amino acids since it was discovered to reduce tetraauric acid (AuCl₄) to Au-NPs. The size of NPs was discovered to be affected by the concentration of L-histidine; the higher the concentration, the smaller NPs [28].

2.2. Polysaccharides.

Dextran is a complex branched polysaccharide composed of many glucose molecules with chains of varying lengths [29]. It is hydrophilic, biocompatible, non-toxic, and used to coat many metal NPs [30]. Chitosan is a polysaccharide made up of glucosamine and N-acetylglucosamine units in a linear structure. Non-parenteral drug delivery using chitosan-based NPs can be used to treat cancer, lung diseases, gastrointestinal disorders, medication delivery to the brain, and eye infections [31]. Gelatin was used to coat gold NPs of various shapes and sizes [32].

2.3. Understanding the role of capping agents.

The growing kinetics of nuclei during the synthesis process dictate the final form of NPs [33]. As a result, NP growth can occur in either a thermodynamically or kinetically controlled manner. In general, isotropic nanocrystal growth results in spheres under thermodynamic control, whereas anisotropic nanocrystal growth results in NPs of diverse forms under kinetic control. NPs are generated in conditions far from thermodynamic equilibrium, in other words. NPs were synthesized in practice by significantly slowing down the rate of precursor decomposition or reduction [34]. When crystal development occurs outside of thermodynamic equilibrium, a slight change in reaction circumstances greatly amplifies variations in surface free energy at various facets, resulting in anisotropic growth at

various facets [35]. In such instances, the adsorption of capping molecules on specific facets might alter the difference in surface free energy, potentially hindering or enhancing development at these aspects. The interaction of biomolecules, particularly peptides, with metal surfaces has been expected to result in nanostructure stabilization, enhancing their usefulness as sensors, biomedical devices, and electronics[36]. Phage-display libraries have been created to generate peptides that can bind to the surface of semiconductor materials in a specific way based on crystallographic orientation and composition[37]. The phage display method identifies the physical relationship between peptide substrate interactions. Peptides could allow for the precise placement and assembly of molecules, expanding the scope of the 'bottom-up' approach to NPs synthesis [37].

3. Types of Nanoparticles

Depending on their morphology, size, and chemical characteristics, NPs are classified into several groups. Some of the most well-known classes of NPs are listed below, based on physical and chemical features [38].

3.1. Carbon-based NPs.

Carbon nanotubes (CNTs) and fullerenes are two main groups of carbon-based NPs.

3.1.1. Fullerenes.

Fullerenes (C₆₀) are spherical carbon molecules made up of carbon atoms that are bound together by sp² hybridization. The spherical structure is made up of around 28 to 1500 carbon atoms, with diameters ranging from 8.2 nm for single layers to 4 - 36 nm for multi-layered fullerenes [39]. Nanomaterials composed of globular hollow cages, such as allotropic forms of carbon, are found in fullerenes. Because of their electrical conductivity, high strength, structure, electron affinity, and adaptability have attracted commercial interest [40].

3.1.2. Graphene.

Graphene is a carbon allotrope. Graphene is a two-dimensional planar hexagonal network of honeycomb lattices composed of carbon atoms. The thickness of a graphene sheet is usually approximately 1 nm [41].

3.1.3. Carbon nanotubes (CNT).

Carbon nanotubes (CNT) are produced from a graphene nano foil with a honeycomb structure of atoms sore into hollow coils to form nanotubes with sizes as tiny as 0.7 nm for single-layered CNT and 100 nm for multi-layered CNT, and lengths tend to range from a few micrometers to several millimeters. The ends can be hollow, or half fullerene molecules can close them[42]. These have a similar structure to a graphite sheet rolling on itself [43]. Because the rolled sheets can have one, two, or multiple walls, they are referred to as single-walled (SWNTs), double-walled (DWNTs), or multi-walled carbon nanotubes (MWNTs). Deposition of carbon precursors, particularly the atomic, is common to synthesize them. Carbons are vaporized from graphite and deposited on metal particles using a laser or an electric arc. Recently, they have been produced using the chemical vapor deposition (CVD) method [44].

3.1.4. Carbon nanofiber.

Carbon nanofiber is produced in the same way as graphene nano foil and CNT. The difference is that it wound into a cone shape as a substitute for regular cylindrical tubes [45].

3.1.5. Carbon black.

An amorphous carbon material usually has a spherical shape with diameters ranging from 20 to 70 nm. They aggregate because the particles interact rapidly, and nearly 500 nm agglomerates are formed [46].

3.2. Metal NPs.

Metal-based nanoparticles are synthesized from metals to nanometric sizes using destructive or constructive processes. Almost all metals have nanoparticles that can be synthesized [47,48]. Aluminum, cadmium, cobalt, copper, gold, iron, lead, silver, and zinc are commonly used for nanoparticle synthesis [47,49,50]. Nanoparticles have distinct properties such as sizes ranging from 10 to 100nm, surface characteristics such as pore size, high surface to volume ratio, surface charge with density, crystalline structures, spherical shapes, color, reactivity, and sensitivity [51,52]. The metals precursors are used for the synthesis of metal NPs. Because of confined surface plasmon resonance (SPR), these NPs have unique optoelectrical characteristics [53,54]. Noble metal and alkali NPs, such as Cu, Au, and Ag, exhibit a noticeable absorption band in the solar electromagnetic spectrum. In today's cutting-edge materials, the synthesis of size and shape-controlled metal NPs is critical [38,55,56].

3.3. Metal oxide nanoparticles synthesis.

Metals like Cu and Ag, for example, can be exceedingly poisonous to bacteria in very low quantities [57]. Due to their biocidal impact, metals have been widely employed as antimicrobial agents in various applications in industry, healthcare, and agriculture in general. Unlike other antibacterial agents, metals are stable under current manufacturing conditions, allowing them to be used as additives [58,59]. These metal-based additives can now be found in various forms, including particles, ions absorbed/exchanged in various carriers, salts, hybrid structures, and so on [60-62]. Many metal oxide nanoparticles, such as ZnO, NiO, MnO₂, TiO₂, Fe₂O₃, and Co₃O₄, have been explored for the electrochemical detection of biomolecules [63]. Furthermore, mixed metal oxides have attracted enough attention in this area. CuO-NPs have unique characteristics that have made them useful in various applications, including super-strong materials, sensors, antibacterial, and catalysts [64]. Due to the high surface area to volume ratio can also contact and interact with other nanoparticles [65]. CuO-NPs have recently been found to have better antibacterial action than Ag-NPs against *E coli* and *B subtilis* [66]. CuO-NPs are commonly utilized in paints and textiles as antibacterial agents since they are polymer-coated [67]. Due to their photolytic capabilities, TiO₂ and ZnO are commonly used. Other interesting metal-oxide NPs are based on CeO₂, CrO₂, MoO₃, Bi₂O₃, and LiCoO₂. CeO₂ is increasingly being used in diesel fuels as a combustion catalyst to enhance emission quality [68]. Iron oxide NPs (IO-NPs) must be highly crystalline, monodisperse, and water-soluble, providing high magnetization values, reproducible quality, and good biocompatibility under biological conditions [69,70]. Nanoparticles of superparamagnetic iron-oxide (SPIO) with a mean crystal size of 50–100 nm and ultra-small superparamagnetic iron-oxide (USPIO) nanoparticles with a size below 50 nm are the two types of superparamagnetic IONP-based

materials now used in medical applications [71]. These two groups of IO-NPs have received much attention in the medical community, especially as the next (possible) generation of MRI contrast agents. They are also being considered as possible medication and gene delivery vectors [72,73]. The use of an external magnetic field can change the biodistribution of these nanoparticles. *In vivo* applications for SPIO-NPs with the proper surface chemistry includes MRI contrast enhancement, tissue healing, immunoassay, biological fluid detoxification, hyperthermia, drug delivery, and cell separation. Nanoparticles with high magnetization values, a size smaller than 100 nm, and a narrow particle diameter distribution are required for all of these biomedical applications [74-76]. SPIONs typically have two structural configurations: (i) a core of magnetic particles (usually magnetite, Fe_3O_4 , or maghemite, $\gamma\text{-Fe}_2\text{O}_3$) coated with a biocompatible polymer or (ii) SPIO-NPs are deposited inside the pores of a porous biocompatible polymer [77]. CuO-NPs are frequently utilized for their antimicrobial and biocidal properties [78]. Strong magnetic dipole-dipole attractions between particles cause magnetic nanoparticles to sediment to lower their enormous surface energy ($>100\text{dyn/cm}$). As a result, stabilizers such as surfactants have been used to modify these particles in order to prevent aggregation [79]. Highly stable aqueous dispersions of IO-NPs have been obtained using polymers as the stabilizer [80]. For practical biomedical applications of SPIO-NPs, the surface of NPs must be modified with nontoxic and biocomposable materials. Multidentate ligands (polymers having several groups capable of attaching to particle surfaces) might improve the colloidal stability of inorganic NPs, such as SIO-NPs, as well as their optical, magnetic, and electrical characteristics [81]. In the visible region of the electromagnetic spectrum, most synthetic and bio-based polymers are transparent, meaning they don't interfere with biological processes. Compared to gadolinium-based contrast agents, SPIO-NPs have a slower renal clearance and higher relaxation values, making them more appealing for imaging [82]. Feridex, Endorem, Combidex, and Sinerem are SPIO-NPs with core sizes of 3–6 nm, and dextran coatings (with 20–150 nm hydrodynamic sizes) have been approved for MRI in the patient. Similarly, drug-loaded SPIO-NPs may be directed to the right target location using an external magnetic field while the particle's bio dispersion is tracked. They are actually theragnostic as a result of this method (therapeutic and diagnostic) [83].

3.4. *Ceramics NPs.*

Ceramic NPs are nonmetallic inorganic solids that are made by heating and cooling. They come in various shapes and sizes, including amorphous, polycrystalline, dense, porous, and hollow. As a result of their usage in applications such as catalysis, photo-degradation of dyes, photo-catalysis, and imaging applications, these NPs are attracting much attention from researchers [84,85].

3.5. *Semiconductor NPs.*

Semiconductor materials have properties halfway between metals and nonmetals, giving them a wide range of uses in the literature [86]. Due to the huge bandgaps of semiconductor NPs, bandgap tuning resulted in significant changes in their properties. As a result, they're crucial in photocatalysis, photo optics, and electronic devices. Due to their optimal bandgap and band edge positions, several semiconductor NPs are particularly efficient in water splitting applications [87,88].

3.6. Polymeric NPs.

These are usually organic-based NPs, and they're referred to as polymer nanoparticles (PNPs) in the literature [89,90]. Typically, they are nano-spherical or nano capsular in form. The former are matrix particles with a solid overall mass, whereas the other molecules are adsorbed at the outside edge of the spherical surface. In the latter case, the solid mass is completely encapsulated within the particle [91]. PNPs are simple to functionalize, and as a result, they have a wide range of uses in the literature[45]. Lipid nanotechnology is a specialized topic concerned with the design and manufacturing of lipid nanoparticles for a number of applications, such as medication delivery and RNA release in cancer [92,93].

4. Synthesis of Nanomaterials

There are three different methods for synthesizing nanomaterials: physical, chemical, and biological Figure 1.

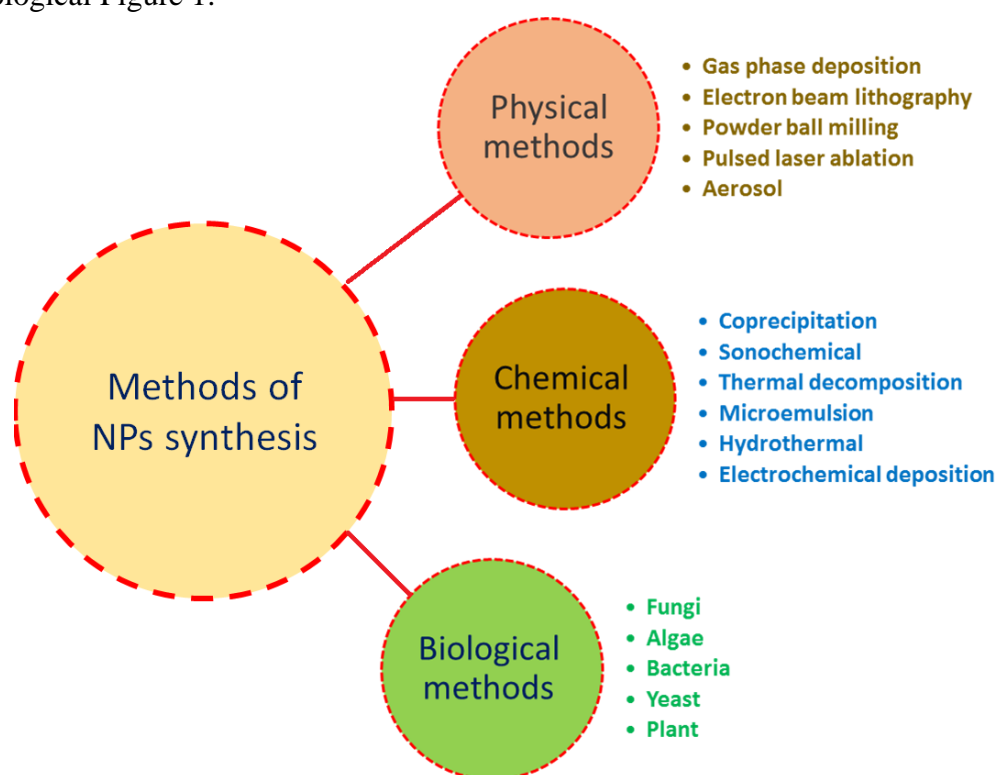


Figure 1. Schematic illustration of the production of nanoparticles via several processes.

4.1. Physical.

Physical route or mechanism includes different methods, e.g., gas-phase deposition, electron beam lithography, pulsed laser ablation, laser-induced pyrolysis, powder ball milling, and aerosol [47,94]. Nanomaterials are generated utilizing a strong laser beam that impacts the target material in laser ablation synthesis [95]. The original material or precursor vaporizes during the laser ablation operation due to the high intensity of the laser irradiation, leading to nanoparticle production. This process can manufacture a wide spectrum of nanomaterials, including carbon nanomaterials, metal nanoparticles, ceramics, and oxide composites [96,97]. Using a focussed beam of light or electrons, lithography is a valuable technology for creating nanoarchitectures. Masked and maskless lithography are the two most common forms of lithography. Using a specified mask or template, masked nanolithography transfers nanopatterns over a vast surface area. Photolithography, soft lithography, nanoimprint

lithography are examples of masked lithography techniques [98,99]. Mechanical milling is a price approach for creating nanoscale products from larger particles. Mechanical milling is an efficient method for blending distinct phases and is useful in creating nanocomposites [100]. Carbon nanoparticles that have been ball-milled are a unique form of nanomaterial that can be used for environmental cleanup, energy storage, and energy conversion [101]. One of the most basic processes for creating nanostructured materials is electrospinning. It is commonly used to make nanofibers out of many materials, most commonly polymers. Hollow polymer and core-shell, organic, inorganic, and hybrid materials have been developed using this technology [102]. Sputtering deposition causes the physical ejection of tiny atom clusters by bombarding the target surface with powerful gaseous ions [103]. Sputtering is appealing because the composition of sputtered nanomaterials is similar to that of the target material, with fewer contaminants, and it is less expensive than electron-beam lithography [104].

4.2. Chemical.

The chemical route includes different methods, e.g., coprecipitation, microemulsion, hydrothermal, electrochemical deposition, sonochemical, and thermal decomposition [47]. Numerous chemical methods are used to synthesize magnetic nanoparticles for medical imaging applications: e.g. microemulsions, sol-gel syntheses, sonochemical reactions, hydrothermal reactions, hydrolysis and thermolysis of precursors, flow injection syntheses, and electrospray syntheses [105-107]. In the production of carbon-based nanomaterials, chemical vapor deposition technologies are crucial. If a precursor has acceptable volatility, high chemical purity, good evaporation stability, cheap cost, non-hazardous, and long shelf life, it is deemed ideal for chemical vapor deposition. Furthermore, its breakdown should not leave any contaminants behind [108]. Ni and Co catalysts produce multilayer graphene in the chemical vapor deposition method, whereas a Cu catalyst produces monolayer graphene. Chemical vapor deposition is a well-known process for manufacturing two-dimensional nanomaterials, and it is an effective approach for producing high-quality nanomaterials in general [109]. The sol-gel method is a wet chemical approach that is widely utilized in nanomaterial development. This technique is used to create a variety of high-quality metal-oxide-based nanomaterials. The sol-gel technique is cost-effective and has a number of additional advantages, including the fact that the material generated is homogenous, the processing temperature is low, and the procedure provides a simple approach to make composites and complicated nanostructures [110]. The reverse micelle approach produces NPs that are very tiny and monodispersed in nature highlights the use of the reverse micelle approach to make magnetic lipase-immobilized NPs [111]. The pore diameters of nanoporous materials can be adjusted by changing the surfactant carbon chain length or adding supplementary pore-expanding agents. The soft template approach may be used to make various nanostructured materials, including mesoporous polymeric, carbonaceous nanospheres, porous aluminas, single-crystal nanorods, and mesoporous N-doped graphene [112]. The microwave-assisted hydrothermal approach, which combines the benefits of both hydrothermal and microwave processes, has lately attracted much interest in engineering nanomaterials [113]. Hydrothermal and solvothermal methods for creating different nano-geometries of materials, such as nanorods, nanowires, nanosheets, and nanospheres, are interesting and practical [114].

4.3. Biological.

The biological route includes different methods, e.g., fungi mediated, algae, bacteria mediated, yeast mediated, etc. [115-117]. Nanoparticles made by a biogenic enzymatic process are significantly superior to those made by chemical methods in various aspects [118]. Even though the latter methods can produce large quantities of NPs with a defined size and shape in a short amount of time, they are complicated, outdated, expensive, and inefficient, and they generate hazardous toxic wastes that are harmful not only to the environment but also to human health [119,120].

4.4. Biosynthesis of NPs using microorganisms.

4.4.1. Synthesis of nanoparticles using Fungi.

Fungi are the largest group among microbes, where are used in multiple applications in different sciences such as bioremediation, enzyme production, nanotechnology, etc. [121-124]. Fungi have sparked a lot of interest in manufacturing metallic nanoparticles since they have several benefits over bacteria in nanoparticle synthesis [125,126]. The simplicity of scaling up and downstream processing, the economic feasibility, and the existence of mycelia, which provides a larger surface area, are all significant benefits [127,128]. A biomineralization mechanism is used in fungal-based NP production, which involves internal and extracellular enzymes and biomolecules reducing various metal ions. Silver has been the metal of choice for the manufacture and research of NPs. In addition, Au, Se, Ti, Cu, and Zn have been identified as the next most important metal ions employed by fungus in the production of NPs. More research on NP biosynthesis has been done on *Fusarium*, *Aspergillus*, *Trichoderma*, *Verticillium*, *Rhizopus*, and *Penicillium* species [126]. The size and form of NPs generated by fungus can be relatively limited or quite diversified, such as Au-NPs produced by *Aspergillus* sp. and Ag-NPs produced by *Fusarium* strain [125,129]. Magnetite NPs have been found to be formed by the pathogenic fungus *F. oxysporum* and fungus *Verticillium* sp. Magnetite (Fe₃O₄) is a common iron oxide with magnetic characteristics [130]. Fungi-produced nanoparticles have been employed in various applications, including medicine, anticancer drugs, antimicrobials, antibiotics, antivirals, diagnostics, antifungals, engineering, biosensors, agriculture, bioimaging, and industry. Agricultural and medicinal applications have been identified as the most common uses of NPs [131]. When compared to bacteria, fungi produce a huge number of nanoparticles. Fungi secrete more proteins, resulting in increased nanoparticle output [132].

4.4.2. Synthesis of nanoparticles using yeast.

Extracellular synthesis of nanoparticles by yeast cell mass might be beneficial in large-scale production and simple downstream processing. This group isolated silver tolerant yeast strain MKY3 by inoculating with aqueous silver nitrate [133]. The formation of Ag-NPs takes place in forced ecological conditions [134]. Different processes used by yeast strains of different genera for nanoparticle formation result in significant differences in size, particle position, mono dispersity, and characteristics [135,136]. These molecules determine the mechanism for the formation of nanoparticles and stabilize the complexes in most of the yeast species studied. Resistance is defined as the ability of a yeast cell to convert absorbed metal ions into complex polymer compounds that are not toxic to the cell [137]. In the mass

production of metal nanoparticles, yeast production is easy to manage in laboratory settings. The rapid growth of yeast strains and the use of basic nutrients have various advantages. *Candida glabrata* and *Saccharomyces pombe* yeast strains have been described to produce intracellular synthesized silver, cadmium sulfide, titanium, selenium, and gold nanoparticles for this purpose [138].

4.4.3. Synthesis of nanoparticles using bacteria.

Research has concentrated primarily on prokaryotes to synthesize metallic nanoparticles [139]. Due to their ubiquity in the environment and their capacity to adapt to harsh situations, bacteria are suitable for study. They are also quick-growing, affordable to cultivate, and easy to manage. Growth parameters such as temperature, oxygenation, and incubation time can be easily regulated. Bacteria are known to synthesize inorganic materials either intracellularly or extracellularly. For example, Ag-NPs are synthesized using microorganisms by the bioreduction process [140]. Metal ions are reduced to nanoscale ranges by extra-reductase enzymes produced by microorganisms [141]. According to a protein assay of microorganisms, the NADH-dependent reductase enzyme is involved in the bioreduction of silver ions to silver nanoparticles. The electrons for the reductase enzyme come from NADH which is then oxidized to NAD⁺. The enzyme is also oxidized by the reduction of Ag⁺ to Ag-NPs at the same time [142,143]. *Pseudomonas stutzeri* was used to produce Ag-NPs outside the cells [144]. In addition, several bacterial strains (Gram-negative and Gram-positive), namely *A. calcoaceticus*, *B. amyloliquefaciens*, *B. flexus*, *B. megaterium*, and *S. aureus* have been used for both extra and intracellular biosynthesis of Ag-NPs. These Ag-NPs are spherical, disk, cuboidal, hexagonal, and triangular. They have been fabricated using culture supernatant, aqueous cell-free extract, or cells [2]. *Rhodopseudomonas capsulata* was shown to produce Au-NPs of various sizes, with the form of the Au-NPs being regulated by pH [145]. Bacteria are thought to be a possible biofactory for producing NPs such as selenium, silver, palladium, gold, platinum, titanium, magnetite, titanium dioxide, cadmium sulfide, and other metal NPs [146-148].

4.4.4. Synthesis of nanoparticles using actinomycetes.

These actinomycetes have a good ability to make antibiotics as secondary metabolites [149]. Actinomycetes have been found to have a significant role in creating metal nanoparticles [150,151]. Biogenic synthesis of metal nanoparticles has been demonstrated using bacteria, fungus, algae, actinomycetes, plants, and other organisms. Actinomycetes are one of the less well-known microorganisms employed in producing metal nanoparticles [152]. However, reports suggest that actinomycetes are effective candidates for the intracellular and extracellular synthesis of metal nanoparticles [153]. Actinomycetes produce nanoparticles with good polydispersity and stability and high biocidal activity against a variety of diseases [154]. *Thermoactinomyete* sp., *Rhodococcus* sp., *Streptomyces viridogens*, *Nocardia farcinica*, *Streptomyces hygroscopicus*, and *Thermomonospora* sp. have all effectively manufactured Au-NPs. *Streptomyces* spp., on the other hand, were used to successfully produce Cu-NPs, Ag-NPs, Mn-NPs, and Zn-NPs [2,155].

4.4.5. Synthesis of nanoparticles using the plant.

Plant parts such as leaves, stems, roots, shoots, flowers, barks, seeds, and their metabolites have been used to synthesize nanoparticles successfully [156-158]. Plants with minimal costs and a high eco-friendliness are highly sophisticated and advantageous to human uses. Using plant extracts such as *Pinus resinosa*, *Cinnamom zeylanicum*, *Ocimum sanctum*, *Anogeissus latifolia*, *Curcuma longa*, *Musa paradisiaca*, *Pulicaria glutinosa*, *Glycine max*, *Doipyros kaki*, *Cinnamomum camphora*, and *Gardenia jasminoides*, green production of Pd-NPs and Pt-NPs has been described [159]. Silver from silver nitrate, zinc oxide from zinc nitrate and zinc acetate, gold from gold chloride, cadmium sulfide, and zinc sulfide from cadmium sulfate and zinc sulfate, and other nanoparticles were manufactured with the assistance of various types of plants and their various components [157]. Recently reported green production of Ag-NPs from Pongamiapinnata seed extract [160]. An absorption maximum of 439 nm confirmed the production of nanoparticles. The zeta potential of the well-dispersed nanoparticles with an average size of 16.4 nm was 23.7 mV, which indicates dispersion and stability [160]. The interaction of Au-NPs with human serum albumin was examined, and helices were shown to be unaffected [161].

5. Controlling the Size and Stabilizing Synthesized Nanoparticles (Optimization)

5.1. Coating or stabilizing of NPs with polymers.

Individual colloidal nanoparticles encapsulated in porous inorganic shells have recently gained a lot of interest [162].

Table 1. A summary of common coating processes and materials used to protect iron oxide cores against corrosion [171].

Coating material	Synthesizing procedure	Experimental conditions	Application/ purpose	Core-shell form of FeO NPs	Advantages
Silver and Gold	In the presence of iron oxide NPs, Au or Ag precursors are reduced	Differentiate according to the solubility, surface chemistry, and size of iron oxide NP cores.	Protect iron oxide NPs from low pH corrosion	Fe ₃ O ₄ /Au and/or Fe ₃ O ₄ /Au/Ag	Additional optical qualities should be included. Gold-silver chemistry can help with organic conjugation.
SiO₂	TEOS is alkaline hydrolyzed in the presence of core NPs	Changing reaction conditions to either porous or dense	Colloid surface modification	Fe ₃ O ₄ /SiO ₂	For bioconjugations, it's compatible with a wide range of chemicals and compounds. Small compounds, such as dyes and drugs, as well as quantum dots, can all be used. Antibody-antigen recognition covalently binds to numerous ligands and biomolecules in target organs. Even without surfactants, it's stable and easy to disperse in an aqueous or organic solution.
TaO_x	By thermal decomposition of iron oleate precursor and fast hydrolysis of TaO _x	In a mixture of Igepal CO-520, NaOH, and other organic solvents	applied in Clinical studies. CT is used to image newly formed blood vessels in tumours, whereas MRI is used to detect the tumor microenvironment.	Fe ₃ O ₄ /TaO _x	CT contrast agent with a low price tag. CT and MRI bifunctional agent Possibility of accurate cancer diagnosis

Coating material	Synthesizing procedure	Experimental conditions	Application/ purpose	Core-shell form of FeO NPs	Advantages
Polymer (both natural and synthetic)	By use of polymerization in the presence of precursors and iron oxide NPs	Similar to the hydrolysis synthesis of silica-coated Fe ₃ O ₄ NPs	To enhance dispersibility in an aqueous medium	Fe ₃ O ₄ and CdSe/ZnS NPs incorporated into the PLGA matrix	It has a protecting and increasing biocompatible functionalization of organic surface
Small molecules	surfactants were produced by thermal decomposition of Fe(CO) ₅ . 4-MC could be directly conjugated with a peptide, c(RGDyK), using the Mannich process.	Oxidation under air	To avoid a large hydrodynamic size	c(RGDyK)-MC-Fe ₃ O ₄	Stable. Target tumor cells with high levels of integrin avb3. For tumor cell detection, the MRI contrast was increased. Fe ₃ O ₄ NPs coated with RGD were shown to be stable in an aqueous solution for months.
Carbon	Hydrocarbon precursors are carbonized. Using a CVD technique at 800°C with nitrogen gas as a shield	annealing at a high temperature that needs to be decreased to enhance the process	Gives cytotoxicity results	Carbon-coated FeCo and/or Fe ₃ O ₄	Both single NPs and tiny NP clusters can be absorbed by cells. both of which have an impact in the measurement of cytotoxicity

Bottom-up techniques at the single-nanoparticle level, while conceptually elegant, have obstacles in large-scale manufacture and use. Solid catalysts are made up of metal nanoparticles distributed on a porous medium. Technical catalysts frequently have irregular spatial distributions and ultra-short interparticle distances [163]. Yang *et al.* used zwitterionic polymers to make Au-NPs. Unfortunately, during the coating process, their particles clumped together. These aggregates were stable in human serum after being coated [164]. Qi *et al.* were able to produce stable NPs with a BSA/chitosan/doxorubicin core under physiological circumstances by adding an extra chitosan coating [165]. Hauser *et al.* [166] used three ways to encapsulate iron oxide nanoparticles with dextran: (1) Two-step approach for making dextran-coated iron oxide nanoparticles. (2) A semi-two-step process for making dextran-coated iron oxide nanoparticles. (3) Simultaneous semi-two-step production of dextran-coated IO-NPs. There are two ways to attach polymers to the IO-NP surface: grafting 'onto' and grafting 'from.' Grafting 'from' involves attaching an initiator to the IO-NPs' surface and growing the polymer from there, whereas grafting 'onto' involves grafting a functional, pre-formed polymer onto IO-NPs *in situ*. Furthermore, grafting 'from' can make keeping the hybrid nanoparticles' integrity in organic solvents [167]. Utilizing live radical polymerization in conjunction with a carefully developed protocol, it is possible to modify IO-NPs using the grafting "from" method [168,169]. Sommertune *et al.* [170] prepared multi-core magnetic hybrid particles based on the ESE method. Other reports show that controlling the size and shape of other nanoparticles by polymer and using them for different applications is possible Table 1. Table 2 showed different polymers for magnetic NP stabilization [171].

Table 2. Different polymers for magnetic NPs to stabilization.

Polymers	Benefits
PEG	PEG improves biocompatibility by immobilizing PEG on the surface noncovalently, increasing NP internalization efficiency and decreasing blood circulation time.
Dextran	colloidal solution stabilization and blood circulation time increasing

Polymers	Benefits
PVP	blood circulation time enhancing and colloidal solution Stabilization
Fatty acids	stability of colloidal and terminal functional carboxyl groups
PVA	particles monodispersing and particles coagulation prevention
Polyacrylic acid	particles biocompatibility improvement, bioadhesion, and stability increasing
Polypeptides	targeting to the cell that is worthy for cytology
Phosphorylcholine	stabilization of colloidal solution and activating coagulation
Poly(d, l-lactide)	high biocompatibility and lowering cytotoxicity
PolyNIPAAm	Delivery of drug and improving cell separation
Chitosan	Biocompatible, utilized in medicine and food, employed in water treatment, polymers, textiles, biotechnology, hydrophilic, and used in agriculture, this natural cationic linear polymer is widely used as a nonviral gene delivery mechanism.
Gelatin	Biocompatible, gelling agent, hydrophilic emulsifier, and used as a natural polymer

6. Characterization of Nanoparticles

6.1. UV-visible spectrometry.

The determination of NP synthesis of various nanoparticles from different methods was analyzed by UV-visible spectroscopy. The production of nanoparticles is clearly indicated by a steady increase in the characteristic peak with increasing reaction time and concentration of biological extracts with salt ions. The UV-vis absorption spectrum of nanosized particles reveals peaks characteristic of the surface plasmon resonance [126].

6.2. Transmission Electron Microscopy (TEM).

The morphology of the nanoparticles was recorded by using a TEM. TEM is based on the electron transmittance principle so that it can provide information of the bulk material from very low to higher magnification. TEM also provides essential information about two or more layer materials, such as the quadrupolar hollow shell structure of NPs observed through TEM [128].

6.3. Particle size and zeta potential.

The zeta potential analyzer was used to detect surface charge. The zeta potential (ZP) is a useful parameter for assessing the behavior of suspended particles in aqueous media, whether for predicting colloidal stability or investigating particle deposition in water cooling process equipment; colloidal stability is influenced by the surface charge and biodistribution of NPs. The nature and behavior of surface groups in solution at a specific pH in the presence of an electrolyte can be qualitatively defined. It can be measured quantitatively as an electrical potential in the interfacial double layer on the surface of suspended NPs. Because of the electrostatic interaction, a high zeta potential value indicates that NPs are dispersion stable. It is an important technique used to determine the size distributions of nanoparticles and use DLS to determine the size distributions of nanoparticles [126].

6.4. Fourier transformation infrared spectroscopy (FTIR).

FTIR is a commonly used method for detecting functional groups in pure substances and mixtures and comparing compounds. The vibrational motion of atoms and molecules is linked to infrared analysis [172].

6.5. X-ray diffraction (XRD).

X-ray fluorescence is a non-destructive analytical method used to find the elemental composition of materials. X-ray diffraction patterns have long been used to identify important aspects in a compound, such as the types and nature of the crystalline phases present. The position (angle) and intensities of the X-ray beam diffraction induced by the sample in XRD can provide information about the sample [49].

6.6. Scanning Electron Microscopy (SEM).

Magnetic nanoparticles' size and shape are examined using SEM. SEM can produce images of three-dimensional objects because, in its regular mode of operation, it records secondary electrons emitted from the sample by the electron beam impinging on it, rather than the electrons flowing through it [63].

7. Applications of Synthesis NPs

7.1. Water treatment.

Nanotechnology has opened up limitless possibilities for purifying water, even in its ionic condition [173]. The numerous nanostructured materials have been created with properties including high aspect ratio, reactivity, controllable pore volume, and electrostatic, hydrophilic, and hydrophobic interactions that are useful in adsorption catalysis, sensing, and optoelectronics [174,175]. Nanoscale metals and their oxides (silver, titanium, gold, and iron) have been widely used in environmental mitigation [176]. Biological contaminants such as bacteria, viruses, and fungi are effectively disinfected by Ag-NPs [177].

7.1.1. Carbon nanotube.

Generally, carbon is one of the most multilateral elements present in the periodic table due to its strength and ability to bond with other elements. Carbon nanotube (CNTs) discovered in 1991 by Iijima has been extensively adapted by many researchers to study show capability into water treatment [178]. Rizzuto, *et al.* [179] use carbon nanotube membranes for water purification. CNT membranes were utilized to direct water desalination or remove salts from water molecules without changing their flow rate [180].

7.1.2. Metal oxides.

Metal oxides such as iron oxide, titanium dioxide, and alumina are effective, low-cost adsorbents for heavy metals and radionuclides [181,182]. The sorption is mainly controlled by the complexation between dissolved metals and the oxygen in metal oxides [183,184]. The great sorption capability, operational simplicity, and resourcefulness of nanosized iron oxides have sparked increased interest in their usage for wastewater treatment [185]. Non-magnetic goethite (-FeOOH) and hematite (-Fe₂O₃), magnetic magnetite (Fe₃O₄) and maghemite (-Fe₂O₃), and hydrous ferric oxides are the phases of iron oxides. In their complex matrixes, goethite and hematite include a variety of geochemically and ecologically significant oxyanions and cations [186]. They have been touted as effective and low-cost adsorbents for the removal of a variety of pollutants [187,188]. ZnO was primarily used as an adsorbent to remove H₂S. Nanosized ZnO has recently been discovered to be capable of eliminating a

variety of pollutants with great performance and selectivity [189]. Rambabu *et al.* created nanosized porous ZnO plates with low pore diameters and a high specific surface area. It exhibited significant and selective adsorption to cationic pollutants, such as various hazardous metals [190]. A significant number of polar sites on the walls of pores within the nanoplates resulted in such strong, structurally increased adsorption [191]. The adsorbed hydrated Cu(II) could partially hydrolyze, forming Cu-O-Cu on the pore walls, thereby multiplying its adsorption capacity, exhibiting Freundlich-type adsorptive activity [192]. At 303 K, the highest capacity of nanosized ZnO for Cd(II) and Hg(II) ions was 387 and 714 mg/g, respectively [193]. The initial adsorption rate was thought to be controlled by film diffusion, followed by pore diffusion. As previously stated, the surface hydroxyl groups of nanosized ZnO have been shown to play a significant role in the adsorption of certain heavy metals [194].

7.1.3. Polymers.

Polymers are exceptional nanomaterial supports because they often have customizable porosity structures, great mechanical qualities, and chemically attached functional groups [195]. Polymer-based nanocomposites (PNCs) are being investigated as potential water and wastewater treatment materials. The inherent advantages of both nanoparticles and the polymeric matrix are frequently combined in PNCs [196]. The use of nanoparticles in the manufacturing process of polymeric membranes has received much attention during the last years, particularly as a new step in flux enhancement and fouling reduction [197,198]. Hybrid membranes comprising inorganic fillers in a polymer matrix are well-known [199]. Common fillers are oxides such as SiO₂ and zeolites [200, 201].

7.2. Medical application.

7.2.1. Drug delivery.

As drug delivery systems, Nanoparticles are capable of uplifting the several crucial properties of free drugs, such as solubility, *in vivo* stability, pharmacokinetics, biodistribution, and enhancing their efficiency [202,203]. Because of their beneficial properties, nanoparticles might be exploited as prospective medication delivery devices in this area. *In vitro* delivery of a hydrophobic fluorophore was achieved using mixed monolayer protected metal clusters as an example of cellular delivery [204,205]. For medication delivery, a variety of nanostructures have been developed. Lipid or polymer particles, liposomes, micelles, Ag-NPs, quantum dots, Au-NPs, silica NPs, and drug nanocrystals are examples of nanostructures or nanocarriers for drug delivery [206]. Peptides, DNA molecules, chemotherapeutic, radioactive, and hyperthermic pharmaceuticals have been delivered using SPIO-NPs assisted drug delivery systems [207]. IO-NPs have been used as nanocarriers for medication and gene delivery in a number of studies [208,209].

Furthermore, by introducing platinum into the IO-NPs cores, the iron-oxide core can be designed to unleash harmful organic molecules [210]. The polymer covering can now be used as a scaffold (reservoir) for the drug or gene cargo, in addition to stabilizing IO-NPs in a biological medium. The loading and release of bioactive compounds from the polymer coating consequently become a key determinant of IO-NPs' nano-carrier efficiency [211]. Covalent coupling, charge complexation, hydrogen bonding, and hydrophobic/hydrophilic interactions are some ways therapeutics can be attached to polymer strands [212]. The nanoparticles' magnetic characteristics were used to boost cell absorption [213]. Nanoparticles in drug

delivery have benefited the medical field thanks to nanotechnology [172]. Nanoparticles can be used to deliver the medicine to targeted cells by placing the drug in the required area and the required dosage. The total drug consumption and side effects are significantly reduced [214]. This method is less expensive and has fewer side effects [2]. Nanotechnology can help with tissue engineering, which involves replicating and repairing damaged tissue. Tissue engineering can be used to replace traditional treatments like artificial implants and organ transplant s[215]. The formation of carbon nanotube scaffolds in bones is one such example [216].

7.2.2. Antimicrobial.

Pathogenic bacteria's resistance to antimicrobial drugs has arisen in recent years, posing a huge challenge to the healthcare business[217,218]. Nanotechnology and biological sciences advancements have made it feasible to develop smart surfaces that reduce infection. Once applied to biomedical devices and medical personnel protective equipment, the nanotechnology-based solutions outlined here may be useful in developing materials that limit or prevent the development of airborne virus droplets [219]. Metal ions and metal-based materials, such as Au-NPs, Se-NPs, Ag-NPs, MgO-NPs, CuO-NPs, TiO₂-NPs, and ZnO-NPs, have been demonstrated in several studies to be effective antimicrobial coatings [219-226]. Metal-oxide nanoparticles' potential antibacterial processes have yet to be fully identified. Ion concentrations, oxidative stress, ROS, and membrane damage have all been discovered to be plausible modes of action against bacteria [227-230].

7.3. Waste management.

Many things are essential for the life and growth of living organisms, but none are more crucial than water. Around 1.2 billion people lack access to clean drinking water, 2.6 billion people struggle to meet basic sanitation needs, and millions of people, particularly children, have died as a result of illnesses spread by unsafe and dirty water [231]. Polymeric-NPs, metal oxide-NPs, metal-NPs, zeolite, carbon nano, self-assembled monolayer on mesoporous-substrates, biopolymers, and others have all been described as nanomaterials that might be employed in wastewater treatment. Adsorption and biosorption, nanofiltration, photocatalysis, disinfection, pathological control, sensing and monitoring, and other nanotechnology-based wastewater remediation pathways are used [232]. Yang *et al.* used algal-bacterial aerobic biological sludge to evaluate chromium Cr(VI) biosorption from synthetic wastewater. They discovered that Cr(VI) biosorption was strongly influenced by pH, with the greatest Cr(VI) biosorption efficiency of algal-bacterial aerobic-granular sludge being 51.0 mg g⁻¹ at pH 2, Cr(VI) [233]. Researchers are now interested in metal-based nanoparticles as adsorbents [234]. Heavy metals, dyes, and ions are commonly removed from wastewater using nanometals and related oxides, such as MgO, Fe₃O₄, MnO₂, TiO₂, ZnO, and CdO [232].

7.4. Agriculture.

Agriculture and food production are being drastically altered by nanotechnology [235,236]. Nanotechnology has the potential to alter current farming techniques [237] significantly. The majority of agrochemicals applied to crops are lost and do not reach the target location due to several factors such as leaching, photolysis, drifting, hydrolysis, and microbial degradation [238]. Nanoparticles and nanocapsules offer a low-cost, site-specific technique to

distribute pesticides and fertilizers while minimizing collateral damage [239]. Nanotechnology is gaining popularity in agriculture because of its capacity to precisely manage and release insecticides, herbicides, and fertilizers [240-243]. Goswami *et al.* found that various manufactured NPs, such as TiO₂-NPs, Al₂O₃-NPs, SiO₂-NPs, and ZnO-NPs, can suppress infections caused by *Sitophilus oryzae* and baculovirus *B. mori* virus in silkworms [244]. Nanosensors for pesticide residue detection have high sensitivity, low detection limits, great selectivity, quick reactions, and small dimensions. They can also determine the soil's quantity of moisture and nutrients [245].

8. Conclusions

Nanoparticles having different characteristics are a prominent type of nanomaterials that have aided in the advancement of nanotechnology. Scientists interested in such approaches have recently developed their nanocomposites due to recent improvements in the characteristics of novel nanomaterials and their applications. This article defined nanotechnology and described the processes for making nanomaterials out of metals, metal oxides, graphene oxides, and polymers. Green approaches, such as plant extracts and microorganism biomolecules, are intriguing strategies that lead to nanoparticle synthesis with reduced or no toxicity compared to other methods. This review opens up new possibilities for producing and utilizing various nanomaterials.

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Conflicts of Interest

The authors declare no conflict of interest.

References

1. Farooqi, Z.U.R.; Qadeer, A.; Hussain, M.M.; Zeeshan, N.; Ilic, P. Characterization and physicochemical properties of nanomaterials. In *Nanomaterials: Synthesis, Characterization, Hazards and Safety*; Elsevier: **2021**, 97-121, <https://doi.org/10.1016/C2020-0-00287-2>.
2. Salem, S.S.; Fouda, A. Green Synthesis of Metallic Nanoparticles and Their Prospective Biotechnological Applications: an Overview. *Biological Trace Element Research* **2021**, *199*, 344-370, <https://doi.org/10.1007/s12011-020-02138-3>.
3. Varghese, R.J.; Parani, S.; Thomas, S.; Oluwafemi, O.S.; Wu, J. Introduction to nanomaterials: synthesis and applications. In *Nanomaterials for Solar Cell Applications*; Elsevier: **2019**, 75-95, <https://doi.org/10.1016/C2016-0-03432-0>.
4. Barik, T.K.; Maity, G.C.; Gupta, P.; Mohan, L.; Santra, T.S. Nanomaterials: An Introduction. *Nanomaterials and Their Biomedical Applications* **2021**, *16*, 1.
5. Singh, B.K.; Lee, S.; Na, K. An overview on metal-related catalysts: metal oxides, nanoporous metals and supported metal nanoparticles on metal organic frameworks and zeolites. *Rare Metals* **2020**, *39*, 751-766, <https://doi.org/10.1007/s12598-019-01205-6>.

6. Salem, S.S.; Fouda, M.M.G.; Fouda, A.; Awad, M.A.; Al-Olayan, E.M.; Allam, A.A.; Shaheen, T.I. Antibacterial, Cytotoxicity and Larvicidal Activity of Green Synthesized Selenium Nanoparticles Using *Penicillium corylophilum*. *Journal of Cluster Science* **2021**, *32*, 351-361, <https://doi.org/10.1007/s10876-020-01794-8>.
7. Khan, S.; Mansoor, S.; Rafi, Z.; Kumari, B.; Shoaib, A.; Saeed, M.; Alshehri, S.; Ghoneim, M.M.; Rahamathulla, M.; Hani, U. A review on nanotechnology: Properties, applications, and mechanistic insights of cellular uptake mechanisms. *Journal of Molecular Liquids* **2021**, 118008, <https://doi.org/10.1016/j.molliq.2021.118008>.
8. Pérez-Hernández, H.; Pérez-Moreno, A.; Sarabia-Castillo, C.; García-Mayagoitia, S.; Medina-Pérez, G.; López-Valdez, F.; Campos-Montiel, R.; Jayanta-Kumar, P.; Fernández-Luqueño, F. Ecological Drawbacks of Nanomaterials Produced on an Industrial Scale: Collateral Effect on Human and Environmental Health. *Water, Air, & Soil Pollution* **2021**, *232*, 1-33, <https://doi.org/10.1007/s11270-021-05370-2>.
9. Singh, R.; Singh, S. Nanomanipulation of consumer goods: effects on human health and environment. In *Nanotechnology in Modern Animal Biotechnology*; Springer: **2019**, 221-254, https://doi.org/10.1007/978-981-13-6004-6_7.
10. Pathakoti, K.; Goodla, L.; Manubolu, M.; Hwang, H.-M. Nanoparticles and Their Potential Applications in Agriculture, Biological Therapies, Food, Biomedical, and Pharmaceutical Industry: A Review. *Nanotechnology and Nanomaterial Applications in Food, Health, and Biomedical Sciences* **2019**, 121-162.
11. Elkodous, M.A.; El-Husseiny, H.M.; El-Sayyad, G.S.; Hashem, A.H.; Doghish, A.S.; Elfadil, D.; Radwan, Y.; El-Zeiny, H.M.; Bedair, H.; Ikhdaier, O.A.; *et al.* Recent advances in waste-recycled nanomaterials for biomedical applications: Waste-to-wealth. *Nanotechnology Reviews* **2021**, *10*, 1662-1739, <https://doi.org/10.1515/ntrev-2021-0099>, <https://doi.org/10.1515/ntrev-2021-0099>.
12. Bayda, S.; Adeel, M.; Tuccinardi, T.; Cordani, M.; Rizzolio, F. The history of nanoscience and nanotechnology: from chemical–physical applications to nanomedicine. *Molecules* **2020**, *25*, 112, <https://doi.org/10.3390/molecules25010112>.
13. Qiu, L.; Zhu, N.; Feng, Y.; Michaelides, E.E.; Żyła, G.; Jing, D.; Zhang, X.; Norris, P.M.; Markides, C.N.; Mahian, O. A review of recent advances in thermophysical properties at the nanoscale: From solid state to colloids. *Physics Reports* **2020**, *843*, 1-81, <https://doi.org/10.1016/j.physrep.2019.12.001>.
14. Chivere, V.T.; Kondiah, P.P.; Choonara, Y.E.; Pillay, V. Nanotechnology-based biopolymeric oral delivery platforms for advanced cancer treatment. *Cancers* **2020**, *12*, 522, <https://doi.org/10.3390/cancers12020522>.
15. El-Naggar, M.E.; Hasanin, M.; Hashem, A.H. Eco-Friendly Synthesis of Superhydrophobic Antimicrobial Film Based on Cellulose Acetate/Polycaprolactone Loaded with the Green Biosynthesized Copper Nanoparticles for Food Packaging Application. *Journal of Polymers and the Environment* **2021**, <https://doi.org/10.1007/s10924-021-02318-9>.
16. Alvandi, N.; Rajabnejad, M.; Taghvaei, Z.; Esfandiari, N. New generation of viral nanoparticles for targeted drug delivery in cancer therapy. *Journal of Drug Targeting* **2021**, 1-15, <https://doi.org/10.1080/1061186X.2021.1949600>.
17. Shaheen, T.I.; Fouda, A.; Salem, S.S. Integration of Cotton Fabrics with Biosynthesized CuO Nanoparticles for Bactericidal Activity in the Terms of Their Cytotoxicity Assessment. *Industrial and Engineering Chemistry Research* **2021**, *60*, 1553-1563, <https://doi.org/10.1021/acs.iecr.0c04880>.
18. Hasanin, M.; Hashem, A.H.; El-Rashedy, A.A.; Kamel, S. Synthesis of novel heterocyclic compounds based on dialdehyde cellulose: characterization, antimicrobial, antitumor activity, molecular dynamics simulation and target identification. *Cellulose* **2021**, *28*, 8355-8374, <https://doi.org/10.1007/s10570-021-04063-7>.
19. Hasanin, M.; Elbahnasawy, M.A.; Shehabeldine, A.M.; Hashem, A.H. Ecofriendly preparation of silver nanoparticles-based nanocomposite stabilized by polysaccharides with antibacterial, antifungal and antiviral activities. *BioMetals* **2021**, *34*, 1313-1328, <https://doi.org/10.1007/s10534-021-00344-7>.
20. Thakur, M.; Poojary, S.; Swain, N. Green Synthesis of Iron Oxide Nanoparticles and Its Biomedical Applications. *Nanotechnology Applications in Health and Environmental Sciences* **2021**, 83-109, https://doi.org/10.1007/978-3-030-64410-9_5.
21. Hashem, A.H.; Al Abboud, M.A.; Alawlaqi, M.M.; Abdelghany, T.M.; Hasanin, M. Synthesis of Nanocapsules Based on Biosynthesized Nickel Nanoparticles and Potato Starch: Antimicrobial, Antioxidant, and Anticancer Activity. *Starch - Stärke n/a*, 2100165, <https://doi.org/10.1002/star.202100165>.
22. Elbasuney, S.; El-Sayyad, G.S.; Tantawy, H.; Hashem, A.H. Promising antimicrobial and antibiofilm activities of reduced graphene oxide-metal oxide (RGO-NiO, RGO-AgO, and RGO-ZnO) nanocomposites. *RSC Advances* **2021**, *11*, 25961-25975, <https://doi.org/10.1039/D1RA04542C>.

23. Shehabeldine, A.M.; Hashem, A.H.; Wassel, A.R.; Hasanin, M. Antimicrobial and Antiviral Activities of Durable Cotton Fabrics Treated with Nanocomposite Based on Zinc Oxide Nanoparticles, Acyclovir, Nanochitosan, and Clove Oil. *Applied Biochemistry and Biotechnology* **2021**, <https://doi.org/10.1007/s12010-021-03649-y>.
24. Campisi, S.; Schiavoni, M.; Chan-Thaw, C.E.; Villa, A. Untangling the role of the capping agent in nanocatalysis: recent advances and perspectives. *Catalysts* **2016**, *6*, 185, <https://doi.org/10.3390/catal6120185>.
25. Sharaf, O.M.; Al-Gamal, M.S.; Ibrahim, G.A.; Dabiza, N.M.; Salem, S.S.; El-ssayad, M.F.; Youssef, A.M. Evaluation and characterization of some protective culture metabolites in free and nano-chitosan-loaded forms against common contaminants of Egyptian cheese. *Carbohydrate Polymers* **2019**, *223*, <https://doi.org/10.1016/j.carbpol.2019.115094>.
26. Wang, L.; Wang, L.; Meng, X.; Xiao, F.S. New strategies for the preparation of sinter-resistant metal-nanoparticle-based catalysts. *Advanced Materials* **2019**, *31*, 1901905, <https://doi.org/10.1002/adma.201901905>.
27. Auría-Soro, C.; Nesma, T.; Juanes-Velasco, P.; Landeira-Viñuela, A.; Fidalgo-Gomez, H.; Acebes-Fernandez, V.; Gongora, R.; Almendral Parra, M.J.; Manzano-Roman, R.; Fuentes, M. Interactions of nanoparticles and biosystems: microenvironment of nanoparticles and biomolecules in nanomedicine. *Nanomaterials* **2019**, *9*, 1365, <https://doi.org/10.3390/nano9101365>.
28. Sharma, P.R.; Sharma, S.K.; Antoine, R.; Hsiao, B.S. Efficient removal of arsenic using zinc oxide nanocrystal-decorated regenerated microfibrillated cellulose scaffolds. *ACS Sustainable Chemistry & Engineering* **2019**, *7*, 6140-6151, <https://doi.org/10.1021/acssuschemeng.8b06356>.
29. Wang, Z.; Li, W.; Ma, J.; Tang, G.; Yang, W.; Xu, F. Functionalized nonionic dextran backbones by atom transfer radical polymerization for efficient gene delivery. *Macromolecules* **2011**, *44*, 230-239, <https://doi.org/10.1021/ma102419e>.
30. Vasić, K.; Knez, Ž.; Konstantinova, E.A.; Kokorin, A.I.; Gyergyek, S.; Leitgeb, M. Structural and magnetic characteristics of carboxymethyl dextran coated magnetic nanoparticles: From characterization to immobilization application. *Reactive and Functional Polymers* **2020**, *148*, 104481.
31. Frank, L.A.; Onzi, G.R.; Morawski, A.S.; Pohlmann, A.R.; Guterres, S.S.; Contri, R.V. Chitosan as a coating material for nanoparticles intended for biomedical applications. *Reactive and Functional Polymers* **2020**, *147*, 104459, <https://doi.org/10.1016/j.reactfunctpolym.2019.104459>.
32. Khodashenas, B.; Ardjmand, M.; Rad, A.S.; Esfahani, M.R. Gelatin-coated gold nanoparticles as an effective pH-sensitive methotrexate drug delivery system for breast cancer treatment. *Materials Today Chemistry* **2021**, *20*, 100474, <https://doi.org/10.1016/j.mtchem.2021.100474>.
33. Du, J.S.; Zhou, W.; Rupich, S.M.; Mirkin, C.A. Twin Pathways: Discerning the Origins of Multiply Twinned Colloidal Nanoparticles. *Angewandte Chemie* **2021**, *133*, 6934-6939, <https://doi.org/10.1002/anie.202015166>.
34. Heinz, H.; Pramanik, C.; Heinz, O.; Ding, Y.; Mishra, R.K.; Marchon, D.; Flatt, R.J.; Estrela-Lopis, I.; Llop, J.; Moya, S. Nanoparticle decoration with surfactants: molecular interactions, assembly, and applications. *Surface Science Reports* **2017**, *72*, 1-58, <https://doi.org/10.1016/j.surfrep.2017.02.001>.
35. Paramasivam, G.; Kayambu, N.; Rabel, A.M.; Sundramoorthy, A.K.; Sundaramurthy, A. Anisotropic noble metal nanoparticles: Synthesis, surface functionalization and applications in biosensing, bioimaging, drug delivery and theranostics. *Acta biomaterialia* **2017**, *49*, 45-65, <https://doi.org/10.1016/j.actbio.2016.11.066>.
36. Park, C.; Park, J.E.; Choi, H.C. Crystallization-induced properties from morphology-controlled organic crystals. *Accounts of chemical research* **2014**, *47*, 2353-2364, <https://doi.org/10.1016/j.actbio.2016.11.066>.
37. Hyman, P.; Denyes, J. Bacteriophages in Nanotechnology: History and Future. *Bacteriophages: Biology, Technology, Therapy* **2021**, 657-687, https://doi.org/10.1007/978-3-319-41986-2_22.
38. Khan, I.; Saeed, K.; Khan, I. Nanoparticles: Properties, applications and toxicities. *Arabian journal of chemistry* **2019**, *12*, 908-931, <https://doi.org/10.1016/j.arabjc.2017.05.011>.
39. Patel, K.D.; Singh, R.K.; Kim, H.-W. Carbon-based nanomaterials as an emerging platform for theranostics. *Materials Horizons* **2019**, *6*, 434-469, <https://doi.org/10.1039/C8MH00966J>.
40. Mallikarjunaiah, S.; Pattabhiramaiah, M.; Metikurki, B. Application of nanotechnology in the bioremediation of heavy metals and wastewater management. In *Nanotechnology for food, agriculture, and environment*; Springer: **2020**, 297-321.
41. Bandyopadhyay, A.; Jana, D. A review on role of tetra-rings in graphene systems and their possible applications. *Reports on Progress in Physics* **2020**, *83*, 056501.

42. Jana, S.; Bandyopadhyay, A.; Datta, S.; Bhattacharya, D.; Debnarayan, J. Emerging properties of carbon based 2D material Beyond graphene. *Journal of Physics: Condensed Matter* **2021**, <https://doi.org/10.1088/1361-648X/ac3075>.
43. Song, R.; Wang, Q.; Mao, B.; Wang, Z.; Tang, D.; Zhang, B.; Zhang, J.; Liu, C.; He, D.; Wu, Z. Flexible graphite films with high conductivity for radio-frequency antennas. *Carbon* **2018**, *130*, 164-169, <https://doi.org/10.1016/j.carbon.2018.01.019>.
44. Mohamed, A.E.-M.A.; Mohamed, M.A. Carbon nanotubes: Synthesis, characterization, and applications. In *Carbon Nanomaterials for Agri-Food and Environmental Applications*; Elsevier: **2020**, 21-32, <https://doi.org/10.1016/B978-0-12-819786-8.00002-5>.
45. Foong, L.K.; Foroughi, M.M.; Mirhosseini, A.F.; Safaei, M.; Jahani, S.; Mostafavi, M.; Ebrahimpoor, N.; Sharifi, M.; Varma, R.S.; Khatami, M. Applications of nano-materials in diverse dentistry regimes. *Rsc Advances* **2020**, *10*, 15430-15460, <https://doi.org/10.1039/D0RA00762E>.
46. Mkhari, O.; Ntuli, T.D.; Coville, N.J.; Nxumalo, E.N.; Maubane-Nkadimeng, M.S. A comparison of fluorescent N-doped carbon dots supported on the surface of hollow and solid carbon spheres, and solid silica spheres. *Diamond and Related Materials* **2021**, 108500.
47. Ijaz, I.; Gilani, E.; Nazir, A.; Bukhari, A. Detail review on chemical, physical and green synthesis, classification, characterizations and applications of nanoparticles. *Green Chemistry Letters and Reviews* **2020**, *13*, 223-245, <https://doi.org/10.1080/17518253.2020.1802517>.
48. Abdelmoneim, H.E.M.; Wassel, M.A.; Elfeky, A.S.; Bendary, S.H.; Awad, M.A.; Salem, S.S.; Mahmoud, S.A. Multiple Applications of CdS/TiO₂ Nanocomposites Synthesized via Microwave-Assisted Sol-Gel. *Journal of Cluster Science* **2021**, <https://doi.org/10.1007/s10876-021-02041-4>.
49. Kumar, J.A.; Krithiga, T.; Manigandan, S.; Sathish, S.; Renita, A.A.; Prakash, P.; Prasad, B.N.; Kumar, T.P.; Rajasimman, M.; Bandhegrahai, A.H. A focus to green synthesis of metal/metal based oxide nanoparticles: Various mechanisms and applications towards ecological approach. *Journal of Cleaner Production* **2021**, 129198, <https://doi.org/10.1016/j.jclepro.2021.129198>.
50. Salem, S.S.; El-Belely, E.F.; Niedbała, G.; Alnoman, M.M.; Hassan, S.E.D.; Eid, A.M.; Shaheen, T.I.; Elkelish, A.; Fouda, A. Bactericidal and in-vitro cytotoxic efficacy of silver nanoparticles (Ag-NPs) fabricated by endophytic actinomycetes and their use as coating for the textile fabrics. *Nanomaterials* **2020**, *10*, 1-20, <https://doi.org/10.3390/nano10102082>.
51. Singh, V.; Yadav, P.; Mishra, V. Recent advances on classification, properties, synthesis, and characterization of nanomaterials. *Green Synthesis of Nanomaterials for Bioenergy Applications* **2020**, 83-97, <https://doi.org/10.1002/9781119576785.ch3>.
52. Kankala, R.K.; Han, Y.H.; Na, J.; Lee, C.H.; Sun, Z.; Wang, S.B.; Kimura, T.; Ok, Y.S.; Yamauchi, Y.; Chen, A.Z. Nanoarchitected structure and surface biofunctionality of mesoporous silica nanoparticles. *Advanced Materials* **2020**, *32*, 1907035, <https://doi.org/10.1002/adma.201907035>.
53. B Aziz, S.; Hussein, G.; Brza, M.; J Mohammed, S.; T Abdulwahid, R.; Raza Saeed, S.; Hassanzadeh, A. Fabrication of interconnected plasmonic spherical silver nanoparticles with enhanced localized surface plasmon resonance (LSPR) peaks using quince leaf extract solution. *Nanomaterials* **2019**, *9*, 1557, <https://doi.org/10.3390/nano9111557>.
54. Fouda, A.; El-Din Hassan, S.; Salem, S.S.; Shaheen, T.I. In-Vitro cytotoxicity, antibacterial, and UV protection properties of the biosynthesized Zinc oxide nanoparticles for medical textile applications. *Microbial Pathogenesis* **2018**, *125*, 252-261, <https://doi.org/10.1016/j.micpath.2018.09.030>.
55. Konsolakis, M.; Lykaki, M. Facet-Dependent Reactivity of Ceria Nanoparticles Exemplified by CeO₂-Based Transition Metal Catalysts: A Critical Review. *Catalysts* **2021**, *11*, 452, <https://doi.org/10.3390/catal11040452>.
56. Ortiz de Zárate, D.; García-Meca, C.; Pinilla-Cienfuegos, E.; Ayúcar, J.A.; Griol, A.; Bellières, L.; Hontañón, E.; Kruijs, F.E.; Martí, J. Green and Sustainable Manufacture of Ultrapure Engineered Nanomaterials. *Nanomaterials* **2020**, *10*, 466, <https://doi.org/10.3390/nano10030466>.
57. Martínez-Alcalá, I.; Bernal, M.P. Environmental impact of metals, metalloids, and their toxicity. *Metalloids in Plants: Advances and Future Prospects* **2020**, 451-488, <https://doi.org/10.1002/9781119487210.ch21>.
58. Karim, N.; Afroj, S.; Lloyd, K.; Oaten, L.C.; Andreeva, D.V.; Carr, C.; Farmery, A.D.; Kim, I.-D.; Novoselov, K.S. Sustainable personal protective clothing for healthcare applications: a review. *ACS nano* **2020**, *14*, 12313-12340, <https://doi.org/10.1021/acs.nano.0c05537>.
59. Singh, P.; Garg, A.; Pandit, S.; Mokkapatil, V.; Mijakovic, I. Antimicrobial effects of biogenic nanoparticles. *Nanomaterials* **2018**, *8*, 1009, <https://doi.org/10.3390/nano8121009>.

60. Silbernagel, C.; Aremu, A.; Ashcroft, I. Using machine learning to aid in the parameter optimisation process for metal-based additive manufacturing. *Rapid Prototyping Journal* **2019**, <https://doi.org/10.1108/RPJ-08-2019-0213>.
61. Favier, I.; Pla, D.; Gómez, M. Metal-based nanoparticles dispersed in glycerol: An efficient approach for catalysis. *Catalysis Today* **2018**, *310*, 98-106, <https://doi.org/10.1016/j.cattod.2017.06.026>.
62. Fouda, A.; Abdel-Maksoud, G.; Abdel-Rahman, M.A.; Salem, S.S.; Hassan, S.E.D.; El-Sadany, M.A.H. Eco-friendly approach utilizing green synthesized nanoparticles for paper conservation against microbes involved in biodeterioration of archaeological manuscript. *International Biodeterioration and Biodegradation* **2019**, *142*, 160-169, <https://doi.org/10.1016/j.ibiod.2019.05.012>.
63. Immanuel, S.; Aparna, T.K.; Sivasubramanian, R. Chapter 5 - Graphene–Metal Oxide Nanocomposite Modified Electrochemical Sensors. In *Graphene-Based Electrochemical Sensors for Biomolecules*, Pandikumar, A., Rameshkumar, P., Eds.; Elsevier: **2019**, 113-138, <https://doi.org/10.1016/C2017-0-02915-4>.
64. Al-Hakkani, M.F. Biogenic copper nanoparticles and their applications: A review. *SN Applied Sciences* **2020**, *2*, 1-20, <https://doi.org/10.1007/s42452-020-2279-1>.
65. Hasanin, M.; Al Abboud, M.A.; Alawlaqi, M.M.; Abdelghany, T.M.; Hashem, A.H. Ecofriendly Synthesis of Biosynthesized Copper Nanoparticles with Starch-Based Nanocomposite: Antimicrobial, Antioxidant, and Anticancer Activities. *Biological Trace Element Research* **2021**, <https://doi.org/10.1007/s12011-021-02812-0>.
66. Metryka, O.; Wasilkowski, D.; Mroziak, A. Insight into the Antibacterial Activity of Selected Metal Nanoparticles and Alterations within the Antioxidant Defence System in *Escherichia coli*, *Bacillus cereus* and *Staphylococcus epidermidis*. *International Journal of Molecular Sciences* **2021**, *22*, 11811, <https://doi.org/10.3390/ijms222111811>.
67. Wang, F.; Guan, W.; Xu, L.; Ding, Z.; Ma, H.; Ma, A.; Terry, N. Effects of nanoparticles on algae: Adsorption, distribution, ecotoxicity and fate. *Applied Sciences* **2019**, *9*, 1534, <https://doi.org/10.3390/app9081534>.
68. Farré, M.; Barceló, D. Chapter 1 - Introduction to the Analysis and Risk of Nanomaterials in Environmental and Food Samples. In *Comprehensive Analytical Chemistry*, Farré, M., Barceló, D., Eds.; Elsevier: **2012**, *59*, 1-32.
69. Storozhuk, L.; Besenhard, M.O.; Mourdikoudis, S.; LaGrow, A.P.; Lees, M.R.; Tung, L.D.; Gavriliadis, A.; Thanh, N.T.K. Stable Iron Oxide Nanoflowers with Exceptional Magnetic Heating Efficiency: Simple and Fast Polyol Synthesis. *ACS Applied Materials & Interfaces* **2021**, *13*, 45870-45880, <https://doi.org/10.1021/acsami.1c12323>.
70. Wallyn, J.; Anton, N.; Vandamme, T.F. Synthesis, Principles, and Properties of Magnetite Nanoparticles for *In vivo* Imaging Applications—A Review. *Pharmaceutics* **2019**, *11*, 601, <https://doi.org/10.3390/pharmaceutics11110601>.
71. Khalid, M.K.; Asad, M.; Henrich-Noack, P.; Sokolov, M.; Hintz, W.; Grigartzik, L.; Zhang, E.; Dityatev, A.; Van Wachem, B.; Sabel, B.A. Evaluation of Toxicity and Neural Uptake *In vitro* and *In vivo* of Superparamagnetic Iron Oxide Nanoparticles. *International Journal of Molecular Sciences* **2018**, *19*, 2613, <https://doi.org/10.3390/ijms19092613>.
72. Frantellizzi, V.; Conte, M.; Pontico, M.; Pani, A.; Pani, R.; De Vincentis, G. New Frontiers in Molecular Imaging with Superparamagnetic Iron Oxide Nanoparticles (SPIONs): Efficacy, Toxicity, and Future Applications. *Nuclear Medicine and Molecular Imaging* **2020**, *54*, 65-80, <https://doi.org/10.1007/s13139-020-00635-w>.
73. Herranz, F.; Morales, M.P.; Rodríguez, I.; Ruiz-Cabello, J. Iron Oxide Nanoparticle-Based MRI Contrast Agents: Characterization and *In vivo* Use. In *Magnetic Characterization Techniques for Nanomaterials*, Kumar, C.S.S.R., Ed.; Springer Berlin Heidelberg: Berlin, Heidelberg, **2017**, 85-120.
74. Elkhenany, H.; Abd Elkodous, M.; Ghoneim, N.I.; Ahmed, T.A.; Ahmed, S.M.; Mohamed, I.K.; El-Badri, N. Comparison of different uncoated and starch-coated superparamagnetic iron oxide nanoparticles: Implications for stem cell tracking. *International Journal of Biological Macromolecules* **2020**, *143*, 763-774, <https://doi.org/10.1016/j.ijbiomac.2019.10.031>.
75. Stanković, A.; Mihailović, J.; Mirković, M.; Radović, M.; Milanović, Z.; Ognjanović, M.; Janković, D.; Antić, B.; Mijović, M.; Vranješ-Đurić, S.; *et al.* Aminosilanized flower-structured superparamagnetic iron oxide nanoparticles coupled to 131I-labeled CC49 antibody for combined radionuclide and hyperthermia

- therapy of cancer. *International Journal of Pharmaceutics* **2020**, *587*, 119628, <https://doi.org/10.1016/j.ijpharm.2020.119628>.
76. Zare, S.; Mehrabani, D.; Jalli, R.; Saedi Moghadam, M.; Manafi, N.; Mehrabani, G.; Jamhiri, I.; Ahadian, S. MRI-Tracking of Dental Pulp Stem Cells *In vitro* and *In vivo* Using Dextran-Coated Superparamagnetic Iron Oxide Nanoparticles. *Journal of Clinical Medicine* **2019**, *8*, 1418, <https://doi.org/10.3390/jcm8091418>.
 77. Chen, B.-W.; He, Y.-C.; Sung, S.-Y.; Le, T.T.H.; Hsieh, C.-L.; Chen, J.-Y.; Wei, Z.-H.; Yao, D.-J. Synthesis and characterization of magnetic nanoparticles coated with polystyrene sulfonic acid for biomedical applications. *Science and Technology of Advanced Materials* **2020**, *21*, 471-481, <https://doi.org/10.1080/14686996.2020.1790032>.
 78. Bezza, F.A.; Tichapondwa, S.M.; Chirwa, E.M.N. Fabrication of monodispersed copper oxide nanoparticles with potential application as antimicrobial agents. *Scientific Reports* **2020**, *10*, 16680, <https://doi.org/10.1038/s41598-020-73497-z>.
 79. Santos, P.J.; Macfarlane, R.J. Reinforcing Supramolecular Bonding with Magnetic Dipole Interactions to Assemble Dynamic Nanoparticle Superlattices. *Journal of the American Chemical Society* **2020**, *142*, 1170-1174, <https://doi.org/10.1021/jacs.9b11476>.
 80. Kim, C.; Lee, J.; Schmucker, D.; Fortner, J.D. Highly stable superparamagnetic iron oxide nanoparticles as functional draw solutes for osmotically driven water transport. *npj Clean Water* **2020**, *3*, 8, <https://doi.org/10.1038/s41545-020-0055-9>.
 81. Hou, Z.; Liu, Y.; Xu, J.; Zhu, J. Surface engineering of magnetic iron oxide nanoparticles by polymer grafting: synthesis progress and biomedical applications. *Nanoscale* **2020**, *12*, 14957-14975, <https://doi.org/10.1039/D0NR03346D>.
 82. Rahim, S.; Jan Iftikhar, F.; Malik, M.I. Chapter 16 - Biomedical applications of magnetic nanoparticles. In *Metal Nanoparticles for Drug Delivery and Diagnostic Applications*, Shah, M.R., Imran, M., Ullah, S., Eds.; Elsevier: **2020**, 301-328.
 83. Noqta, O.A.; Aziz, A.A.; Usman, I.A.; Bououdina, M. Recent Advances in Iron Oxide Nanoparticles (IONPs): Synthesis and Surface Modification for Biomedical Applications. *Journal of Superconductivity and Novel Magnetism* **2019**, *32*, 779-795, <https://doi.org/10.1007/s10948-018-4939-6>.
 84. Zeng, X.; Li, E.; Xia, G.; Xie, N.; Shen, Z.-Y.; Moskovits, M.; Yu, R. Silica-based ceramics toward electromagnetic microwave absorption. *Journal of the European Ceramic Society* **2021**, *41*, 7381-7403, <https://doi.org/10.1016/j.jeurceramsoc.2021.08.009>.
 85. Ayode Otitoju, T.; Ugochukwu Okoye, P.; Chen, G.; Li, Y.; Onyeka Okoye, M.; Li, S. Advanced ceramic components: Materials, fabrication, and applications. *Journal of Industrial and Engineering Chemistry* **2020**, *85*, 34-65, <https://doi.org/10.1016/j.jiec.2020.02.002>.
 86. Terna, A.D.; Elemike, E.E.; Mbonu, J.I.; Osafile, O.E.; Ezeani, R.O. The future of semiconductor nanoparticles: Synthesis, properties and applications. *Materials Science and Engineering: B* **2021**, *272*, 115363, <https://doi.org/10.1016/j.mseb.2021.115363>.
 87. Abdullah, B.J. Size effect of band gap in semiconductor nanocrystals and nanostructures from density functional theory within HSE06. *Materials Science in Semiconductor Processing* **2022**, *137*, 106214, <https://doi.org/10.1016/j.mssp.2021.106214>.
 88. Fang, J.; Zhou, Z.; Xiao, M.; Lou, Z.; Wei, Z.; Shen, G. Recent advances in low-dimensional semiconductor nanomaterials and their applications in high-performance photodetectors. *InfoMat* **2020**, *2*, 291-317, <https://doi.org/10.1002/inf2.12067>.
 89. Madkour, L.H. Examples of Nanomaterials with Various Morphologies. In *Nanoelectronic Materials: Fundamentals and Applications*, Madkour, L.H., Ed.; Springer International Publishing: Cham, **2019**, 141-164, https://doi.org/10.1007/978-3-030-21621-4_6.
 90. Dacrory, S.; Hashem, A.H.; Hasanin, M. Synthesis of cellulose based amino acid functionalized nano-biocomplex: Characterization, antifungal activity, molecular docking and hemocompatibility. *Environmental Nanotechnology, Monitoring & Management* **2021**, *15*, 100453, <https://doi.org/10.1016/j.enmm.2021.100453>.
 91. Saifullah, M.; Shishir, M.R.I.; Ferdowsi, R.; Tanver Rahman, M.R.; Van Vuong, Q. Micro and nano encapsulation, retention and controlled release of flavor and aroma compounds: A critical review. *Trends in Food Science & Technology* **2019**, *86*, 230-251, <https://doi.org/10.1016/j.tifs.2019.02.030>.
 92. Noore, S.; Rastogi, N.K.; O'Donnell, C.; Tiwari, B. Novel Bioactive Extraction and Nano-Encapsulation. *Encyclopedia* **2021**, *1*, 632-664, <https://doi.org/10.3390/encyclopedia1030052>.

93. Husen, A. Chapter 1 - Introduction and techniques in nanomaterials formulation. In *Nanomaterials for Agriculture and Forestry Applications*, Husen, A., Jawaid, M., Eds.; Elsevier: **2020**, 1-14, <https://doi.org/10.1016/C2018-0-02349-X>.
94. Rane, A.V.; Kanny, K.; Abitha, V.K.; Thomas, S. Chapter 5 - Methods for Synthesis of Nanoparticles and Fabrication of Nanocomposites. In *Synthesis of Inorganic Nanomaterials*, Mohan Bhagyaraj, S., Oluwafemi, O.S., Kalarikkal, N., Thomas, S., Eds.; Woodhead Publishing: **2018**, 121-139.
95. Zhang, J.; Chaker, M.; Ma, D. Pulsed laser ablation based synthesis of colloidal metal nanoparticles for catalytic applications. *Journal of Colloid and Interface Science* **2017**, *489*, 138-149, <https://doi.org/10.1016/j.jcis.2016.07.050>.
96. Ismail, R.A.; Mohsin, M.H.; Ali, A.K.; Hassoon, K.I.; Erten-Ela, S. Preparation and characterization of carbon nanotubes by pulsed laser ablation in water for optoelectronic application. *Physica E: Low-dimensional Systems and Nanostructures* **2020**, *119*, 113997, <https://doi.org/10.1016/j.physe.2020.113997>.
97. Duque, J.S.; Madrigal, B.M.; Riascos, H.; Avila, Y.P. Colloidal Metal Oxide Nanoparticles Prepared by Laser Ablation Technique and Their Antibacterial Test. *Colloids and Interfaces* **2019**, *3*, 25, <https://doi.org/10.3390/colloids3010025>.
98. Xu, K.; Chen, J. High-resolution scanning probe lithography technology: a review. *Applied Nanoscience* **2020**, *10*, 1013-1022, <https://doi.org/10.1007/s13204-019-01229-5>.
99. Garg, V.; Mote, R.G.; Fu, J. Facile fabrication of functional 3D micro-nano architectures with focused ion beam implantation and selective chemical etching. *Applied Surface Science* **2020**, *526*, 146644, <https://doi.org/10.1016/j.apsusc.2020.146644>.
100. Zhuang, S.; Lee, E.S.; Lei, L.; Nunna, B.B.; Kuang, L.; Zhang, W. Synthesis of nitrogen-doped graphene catalyst by high-energy wet ball milling for electrochemical systems. *International Journal of Energy Research* **2016**, *40*, 2136-2149, <https://doi.org/10.1002/er.3595>.
101. Lyu, H.; Gao, B.; He, F.; Ding, C.; Tang, J.; Crittenden, J.C. Ball-Milled Carbon Nanomaterials for Energy and Environmental Applications. *ACS Sustainable Chemistry & Engineering* **2017**, *5*, 9568-9585, <https://doi.org/10.1021/acssuschemeng.7b02170>.
102. Kumar, P.S.; Sundaramurthy, J.; Sundarajan, S.; Babu, V.J.; Singh, G.; Allakhverdiev, S.I.; Ramakrishna, S. Hierarchical electrospun nanofibers for energy harvesting, production and environmental remediation. *Energy & Environmental Science* **2014**, *7*, 3192-3222, <https://doi.org/10.1039/C4EE00612G>.
103. Son, H.H.; Seo, G.H.; Jeong, U.; Shin, D.Y.; Kim, S.J. Capillary wicking effect of a Cr-sputtered superhydrophilic surface on enhancement of pool boiling critical heat flux. *International Journal of Heat and Mass Transfer* **2017**, *113*, 115-128, <https://doi.org/10.1016/j.ijheatmasstransfer.2017.05.055>.
104. Nie, M.; Sun, K.; Meng, D.D. Formation of metal nanoparticles by short-distance sputter deposition in a reactive ion etching chamber. *Journal of Applied Physics* **2009**, *106*, 054314, <https://doi.org/10.1063/1.3211326>.
105. Elfeky, A.S.; Salem, S.S.; Elzaref, A.S.; Owda, M.E.; Eladawy, H.A.; Saeed, A.M.; Awad, M.A.; Abou-Zeid, R.E.; Fouda, A. Multifunctional cellulose nanocrystal /metal oxide hybrid, photo-degradation, antibacterial and larvicidal activities. *Carbohydrate Polymers* **2020**, *230*, <https://doi.org/10.1016/j.carbpol.2019.115711>.
106. Kudr, J.; Haddad, Y.; Richtera, L.; Heger, Z.; Cernak, M.; Adam, V.; Zitka, O. Magnetic Nanoparticles: From Design and Synthesis to Real World Applications. *Nanomaterials* **2017**, *7*, 243, <https://doi.org/10.3390/nano7090243>.
107. Shaheen, T.I.; Salem, S.S.; Zaghoul, S. A New Facile Strategy for Multifunctional Textiles Development through *in situ* Deposition of SiO₂/TiO₂ Nanosols Hybrid. *Industrial and Engineering Chemistry Research* **2019**, *58*, 20203-20212, <https://doi.org/10.1021/acs.iecr.9b04655>.
108. Malandrino, G. Chemical Vapour Deposition. Precursors, Processes and Applications. Edited by Anthony C. Jones and Michael L. Hitchman. *Angewandte Chemie International Edition* **2009**, *48*, 7478-7479, <https://doi.org/10.1002/anie.200903570>.
109. Wu, Q.; Wongwiriyan, W.; Park, J.-H.; Park, S.; Jung, S.J.; Jeong, T.; Lee, S.; Lee, Y.H.; Song, Y.J. *In situ* chemical vapor deposition of graphene and hexagonal boron nitride heterostructures. *Current Applied Physics* **2016**, *16*, 1175-1191, <https://doi.org/10.1016/j.cap.2016.04.024>.
110. Parashar, M.; Shukla, V.K.; Singh, R. Metal oxides nanoparticles via sol-gel method: a review on synthesis, characterization and applications. *Journal of Materials Science: Materials in Electronics* **2020**, *31*, 3729-3749, <https://doi.org/10.1007/s10854-020-02994-8>.

111. Yi, S.; Dai, F.; Zhao, C.; Si, Y. A reverse micelle strategy for fabricating magnetic lipase-immobilized nanoparticles with robust enzymatic activity. *Scientific Reports* **2017**, *7*, 9806, <https://doi.org/10.1038/s41598-017-10453-4>.
112. Baig, N.; Kammakakam, I.; Falath, W. Nanomaterials: a review of synthesis methods, properties, recent progress, and challenges. *Materials Advances* **2021**, *2*, 1821-1871, <https://doi.org/10.1039/D0MA00807A>.
113. Meng, L.-Y.; Wang, B.; Ma, M.-G.; Lin, K.-L. The progress of microwave-assisted hydrothermal method in the synthesis of functional nanomaterials. *Materials Today Chemistry* **2016**, *1-2*, 63-83, <https://doi.org/10.1016/j.mtchem.2016.11.003>.
114. Dong, Y.; Du, X.-q.; Liang, P.; Man, X.-l. One-pot solvothermal method to fabricate 1D-VS4 nanowires as anode materials for lithium ion batteries. *Inorganic Chemistry Communications* **2020**, *115*, 107883, <https://doi.org/10.1016/j.inoche.2020.107883>.
115. Saravanan, A.; Kumar, P.S.; Karishma, S.; Vo, D.-V.N.; Jeevanantham, S.; Yaashikaa, P.R.; George, C.S. A review on biosynthesis of metal nanoparticles and its environmental applications. *Chemosphere* **2021**, *264*, 128580, <https://doi.org/10.1016/j.chemosphere.2020.128580>.
116. Eid, A.M.; Fouda, A.; Niedbała, G.; Hassan, S.E.D.; Salem, S.S.; Abdo, A.M.; Hetta, H.F.; Shaheen, T.I. Endophytic streptomyces laurentii mediated green synthesis of Ag-NPs with antibacterial and anticancer properties for developing functional textile fabric properties. *Antibiotics* **2020**, *9*, 1-18, <https://doi.org/10.3390/antibiotics9100641>.
117. Alsharif, S.M.; Salem, S.S.; Abdel-Rahman, M.A.; Fouda, A.; Eid, A.M.; El-Din Hassan, S.; Awad, M.A.; Mohamed, A.A. Multifunctional properties of spherical silver nanoparticles fabricated by different microbial taxa. *Heliyon* **2020**, *6*, <https://doi.org/10.1016/j.heliyon.2020.e03943>.
118. Iqbal, J.; Abbasi, B.A.; Ahmad, R.; Shahbaz, A.; Zahra, S.A.; Kanwal, S.; Munir, A.; Rabbani, A.; Mahmood, T. Biogenic synthesis of green and cost effective iron nanoparticles and evaluation of their potential biomedical properties. *Journal of Molecular Structure* **2020**, *1199*, 126979, <https://doi.org/10.1016/j.molstruc.2019.126979>.
119. Khan, S.; Naushad, M.; Al-Gheethi, A.; Iqbal, J. Engineered nanoparticles for removal of pollutants from wastewater: Current status and future prospects of nanotechnology for remediation strategies. *Journal of Environmental Chemical Engineering* **2021**, *9*, 106160, <https://doi.org/10.1016/j.jece.2021.106160>.
120. Ndolomingo, M.J.; Bingwa, N.; Meijboom, R. Review of supported metal nanoparticles: synthesis methodologies, advantages and application as catalysts. *Journal of Materials Science* **2020**, *55*, 6195-6241, <https://doi.org/10.1007/s10853-020-04415-x>.
121. Salem, S.S.; Mohamed, A.A.; El-Gamal, M.S.; Talat, M.; Fouda, A. Biological decolorization and degradation of azo dyes from textile wastewater effluent by *Aspergillus niger*. *Egyptian Journal of Chemistry* **2019**, *62*, 1799-1813, <https://doi.org/10.21608/EJCHEM.2019.11720.1747>.
122. Selim, M.T.; Salem, S.S.; Mohamed, A.A.; El-Gamal, M.S.; Awad, M.F.; Fouda, A. Biological treatment of real textile effluent using *aspergillus flavus* and *fusarium oxysporium* and their consortium along with the evaluation of their phytotoxicity. *Journal of Fungi* **2021**, *7*, <https://doi.org/10.3390/jof7030193>.
123. Ahmed, N.E.; Salem, S.S.; Hashem, A.H. Statistical optimization, partial purification, and characterization of phytase produced from *talaromyces purpureogenus* nsa20 using potato peel waste and its application in dyes de-colorization. *Biointerface Research in Applied Chemistry* **2022**, *12*, 4417-4431, <https://doi.org/10.33263/BRIAC124.44174431>.
124. Mohamed, A.A.; Saad, E.; Fouda, A.; Elgamal, M.S.; Salem, S.S. Extracellular biosynthesis of silver nanoparticles using *Aspergillus* sp. and evaluation of their antibacterial and cytotoxicity. *Journal of Applied Life Sciences International* **2017**, *1-12*, <https://doi.org/10.9734/JALSI/2017/33491>.
125. Mohamed, A.A.; Fouda, A.; Elgamal, M.S.; El-Din Hassan, S.; Shaheen, T.I.; Salem, S.S. Enhancing of cotton fabric antibacterial properties by silver nanoparticles synthesized by new egyptian strain *fusarium keratoplaticum* A1-3. *Egyptian Journal of Chemistry* **2017**, *60*, 63-71, <https://doi.org/10.21608/ejchem.2017.1626.1137>.
126. Shaheen, T.I.; Salem, S.S.; Fouda, A. Current Advances in Fungal Nanobiotechnology: Mycofabrication and Applications. In *Microbial Nanobiotechnology: Principles and Applications*, Lateef, A., Gueguim-Kana, E.B., Dasgupta, N., Ranjan, S., Eds.; Springer Singapore: Singapore, **2021**, 113-143.
127. Ahmed, S.F.; Mofijur, M.; Rafa, N.; Chowdhury, A.T.; Chowdhury, S.; Nahrin, M.; Islam, A.B.M.S.; Ong, H.C. Green approaches in synthesising nanomaterials for environmental nanobioremediation: Technological advancements, applications, benefits and challenges. *Environmental Research* **2022**, *204*, 111967, <https://doi.org/10.1016/j.envres.2021.111967>.

128. Mohamed, A.A.; Fouda, A.; Abdel-Rahman, M.A.; Hassan, S.E.D.; El-Gamal, M.S.; Salem, S.S.; Shaheen, T.I. Fungal strain impacts the shape, bioactivity and multifunctional properties of green synthesized zinc oxide nanoparticles. *Biocatalysis and Agricultural Biotechnology* **2019**, *19*, <https://doi.org/10.1016/j.bcab.2019.101103>.
129. Shen, W.; Qu, Y.; Pei, X.; Li, S.; You, S.; Wang, J.; Zhang, Z.; Zhou, J. Catalytic reduction of 4-nitrophenol using gold nanoparticles biosynthesized by cell-free extracts of *Aspergillus* sp. WL-Au. *Journal of hazardous materials* **2017**, *321*, 299-306. <https://doi.org/10.1016/j.jhazmat.2016.07.051>
130. Jacinto, M.J.; Silva, V.C.; Valladão, D.M.S.; Souto, R.S. Biosynthesis of magnetic iron oxide nanoparticles: a review. *Biotechnology Letters* **2021**, *43*, 1-12, <https://doi.org/10.1007/s10529-020-03047-0>.
131. Dorcheh, S.K.; Vahabi, K. Biosynthesis of Nanoparticles by Fungi: Large-Scale Production. In *Fungal Metabolites*, Mérillon, J.-M., Ramawat, K.G., Eds.; Springer International Publishing: Cham, **2016**, 1-20, <https://doi.org/10.1016/j.heliyon.2021.e08480>.
132. Danaraj, J.; Periakaruppan, R.; Usha, R.; Venil, C.K.; Shami, A. Chapter 15 - Mycogenic nanoparticles: Synthesis, characterizations and applications. In *Agri-Waste and Microbes for Production of Sustainable Nanomaterials*, Abd-Elsalam, K.A., Periakaruppan, R., Rajeshkumar, S., Eds.; Elsevier **2022**, 357-373, <https://doi.org/10.1016/B978-0-12-823575-1.00005-6>.
133. Sharma, J.; Singh, V.K.; Kumar, A.; Shankarayan, R.; Mallubhotla, S., Patra, J.K., Das, G., Shin, H.-S. Role of Silver Nanoparticles in Treatment of Plant Diseases. In *Microbial Biotechnology: Volume 2. Application in Food and Pharmacology*, Eds.; Springer Singapore: Singapore, **2018**, 435-454.
134. Olobayotan, I.; Akin-Osanaiye, B. Biosynthesis of silver nanoparticles using baker's yeast, *Saccharomyces cerevisiae* and its antibacterial activities. *Access Microbiology* **2019**, *1*, <https://doi.org/10.1099/acmi.ac2019.po0316>.
135. Sivaraj, A.; Kumar, V.; Sunder, R.; Parthasarathy, K.; Kasivelu, G. Commercial Yeast Extracts Mediated Green Synthesis of Silver Chloride Nanoparticles and their Anti-mycobacterial Activity. *Journal of Cluster Science* **2020**, *31*, 287-291, <https://doi.org/10.1007/s10876-019-01626-4>.
136. Skalickova, S.; Baron, M.; Sochor, J. Nanoparticles Biosynthesized by Yeast: A Review of their application. *KVASNY PRUMYSL* **2017**, *63*, 290–292, <https://doi.org/10.18832/kp201727>.
137. Shu, M.; He, F.; Li, Z.; Zhu, X.; Ma, Y.; Zhou, Z.; Yang, Z.; Gao, F.; Zeng, M. Biosynthesis and Antibacterial Activity of Silver Nanoparticles Using Yeast Extract as Reducing and Capping Agents. *Nanoscale Research Letters* **2020**, *15*, 14, <https://doi.org/10.1186/s11671-019-3244-z>.
138. Boroumand Moghaddam, A.; Namvar, F.; Moniri, M.; Azizi, S.; Mohamad, R. Nanoparticles biosynthesized by fungi and yeast: a review of their preparation, properties, and medical applications. *Molecules* **2015**, *20*, 16540-16565, <https://doi.org/10.3390/molecules200916540>.
139. Omran, B.A. Prokaryotic Microbial Synthesis of Nanomaterials (The World of Unseen). In *Nanobiotechnology: A Multidisciplinary Field of Science*, Omran, B.A., Ed.; Springer International Publishing: Cham, **2020**, 37-79.
140. Maroufpour, N.; Alizadeh, M.; Hatami, M.; Asgari Lajayer, B., Prasad, R., Biological Synthesis of Nanoparticles by Different Groups of Bacteria. In *Microbial Nanobionics: Volume 1, State-of-the-Art*, Ed.; Springer International Publishing: Cham, **2019**, 63-85, https://doi.org/10.1007/978-3-030-16383-9_3.
141. Fang, X.; Wang, Y.; Wang, Z.; Jiang, Z.; Dong, M. Microorganism Assisted Synthesized Nanoparticles for Catalytic Applications. *Energies* **2019**, *12*, 190.
142. Ali, J.; Ali, N.; Wang, L.; Waseem, H.; Pan, G. Revisiting the mechanistic pathways for bacterial mediated synthesis of noble metal nanoparticles. *Journal of Microbiological Methods* **2019**, *159*, 18-25, <https://doi.org/10.1016/j.mimet.2019.02.010>.
143. Mukherjee, K.; Gupta, R.; Kumar, G.; Kumari, S.; Biswas, S.; Padmanabhan, P. Synthesis of silver nanoparticles by *Bacillus clausii* and computational profiling of nitrate reductase enzyme involved in production. *Journal of Genetic Engineering and Biotechnology* **2018**, *16*, 527-536, <https://doi.org/10.1016/j.jgeb.2018.04.004>.
144. Desai, M.P.; Patil, R.V.; Pawar, K.D. Selective and sensitive colorimetric detection of platinum using *Pseudomonas stutzeri* mediated optimally synthesized antibacterial silver nanoparticles. *Biotechnology Reports* **2020**, *25*, e00404, <https://doi.org/10.1016/j.btre.2019.e00404>.
145. He, S.; Guo, Z.; Zhang, Y.; Zhang, S.; Wang, J.; Gu, N. Biosynthesis of gold nanoparticles using the bacteria *Rhodospseudomonas capsulata*. *Materials Letters* **2007**, *61*, 3984-3987, <https://doi.org/10.1016/j.matlet.2007.01.018>.

146. Iravani, S. Bacteria in Nanoparticle Synthesis: Current Status and Future Prospects. *International Scholarly Research Notices* **2014**, *2014*, 359316, <https://doi.org/10.1155/2014/359316>.
147. Elbahnasawy, M.A.; Shehabeldine, A.M.; Khatatb, A.M.; Amin, B.H.; Hashem, A.H. Green biosynthesis of silver nanoparticles using novel endophytic *Rothia endophytica*: Characterization and anticandidal activity. *Journal of Drug Delivery Science and Technology* **2021**, *62*, 102401, <https://doi.org/10.1016/j.jddst.2021.102401>.
148. Hashem, A.H.; Abdelaziz, A.M.; Askar, A.A.; Fouda, H.M.; Khalil, A.M.A.; Abd-Elsalam, K.A.; Khaleil, M.M. Bacillus megaterium-Mediated Synthesis of Selenium Nanoparticles and Their Antifungal Activity against *Rhizoctonia solani* in Faba Bean Plants. *Journal of Fungi* **2021**, *7*, 195.
149. Jagannathan, S.V.; Manemann, E.M.; Rowe, S.E.; Callender, M.C.; Soto, W. Marine Actinomycetes, New Sources of Biotechnological Products. *Marine Drugs* **2021**, *19*, 365, <https://doi.org/10.3390/md19070365>.
150. Kumari, S.; Tehri, N.; Gahlaut, A.; Hooda, V. Actinomycetes mediated synthesis, characterization, and applications of metallic nanoparticles. *Inorganic and Nano-Metal Chemistry* **2021**, *51*, 1386-1395, <https://doi.org/10.1080/24701556.2020.1835978>.
151. Hassan, S.E.D.; Fouda, A.; Radwan, A.A.; Salem, S.S.; Barghoth, M.G.; Awad, M.A.; Abdo, A.M.; El-Gamal, M.S. Endophytic actinomycetes *Streptomyces* spp mediated biosynthesis of copper oxide nanoparticles as a promising tool for biotechnological applications. *Journal of Biological Inorganic Chemistry* **2019**, <https://doi.org/10.1007/s00775-019-01654-5>.
152. Gupta, A.; Singh, D.; Singh, S.K.; Singh, V.K.; Singh, A.V.; Kumar, A. 10 - Role of actinomycetes in bioactive and nanoparticle synthesis. In *Role of Plant Growth Promoting Microorganisms in Sustainable Agriculture and Nanotechnology*, Kumar, A., Singh, A.K., Choudhary, K.K., Eds.; Woodhead Publishing: **2019**, 163-182.
153. Venkateswaran S.P.; Palaniswamy, V.K.; Vishvanand, R.; Periakaruppan, R. Chapter 16 - Actinomycetes-assisted nanoparticles: Synthesis and applications. In *Agri-Waste and Microbes for Production of Sustainable Nanomaterials*, Abd-Elsalam, K.A., Periakaruppan, R., Rajeshkumar, S., Eds.; Elsevier: **2022**, 375-395, <https://doi.org/10.1016/B978-0-12-823575-1.00017-2>
154. Mabrouk, M.; Elkhooly, T.A.; Amer, S.K. Actinomycete strain type determines the monodispersity and antibacterial properties of biogenically synthesized silver nanoparticles. *Journal of Genetic Engineering and Biotechnology* **2021**, *19*, 57, <https://doi.org/10.1186/s43141-021-00153-y>.
155. El-Gamal, M.S.; Salem, S.S.; Abdo, A.M. Biosynthesis, characterization, and antimicrobial activities of silver nanoparticles synthesized by endophytic *Streptomyces* sp. *J. Biotechnol* **2018**, *56*, 69-85.
156. Aboyewa, J.A.; Sibuyi, N.R.S.; Meyer, M.; Oguntibeju, O.O. Green Synthesis of Metallic Nanoparticles Using Some Selected Medicinal Plants from Southern Africa and Their Biological Applications. *Plants* **2021**, *10*, 1929, <https://doi.org/10.3390/plants10091929>.
157. Venkat Kumar, S.; Rajeshkumar, S. Chapter 2 - Plant-Based Synthesis of Nanoparticles and Their Impact. In *Nanomaterials in Plants, Algae, and Microorganisms*, Tripathi, D.K., Ahmad, P., Sharma, S., Chauhan, D.K., Dubey, N.K., Eds.; Academic Press: **2018**, 33-57, <https://doi.org/10.1016/B978-0-12-811487-2.00002-5>.
158. Iashin, I.; Hasanin, M.; Hassan, S.A.M.; Hashem, A.H. Green biosynthesis of zinc and selenium oxide nanoparticles using callus extract of *Ziziphus spina-christi*: characterization, antimicrobial, and antioxidant activity. *Biomass Conversion and Biorefinery* **2021**, <https://doi.org/10.1007/s13399-021-01873-4>.
159. Siddiqi, K.S.; Husen, A. Green synthesis, characterization and uses of palladium/platinum nanoparticles. *Nanoscale research letters* **2016**, *11*, 1-13, <https://doi.org/10.1186/s11671-016-1695-z>.
160. Paul, M.; Londhe, V.Y. Pongamia pinnata seed extract-mediated green synthesis of silver nanoparticles: Preparation, formulation and evaluation of bactericidal and wound healing potential. *Applied Organometallic Chemistry* **2019**, *33*, e4624, <https://doi.org/10.1002/aoc.4624>.
161. Maji, A.; Beg, M.; Das, S.; Chandra Jana, G.; Jha, P.K.; Islam, M.M.; Hossain, M. Spectroscopic study on interaction of *Nymphaea nouchali* leaf extract mediated bactericidal gold nanoparticles with human serum albumin. *Journal of Molecular Structure* **2019**, *1179*, 685-693, <https://doi.org/10.1016/j.molstruc.2018.11.055>.
162. Gao, C.; Lyu, F.; Yin, Y. Encapsulated Metal Nanoparticles for Catalysis. *Chemical Reviews* **2021**, *121*, 834-881, <https://doi.org/10.1021/acs.chemrev.0c00237>.
163. Prieto, G.; Zečević, J.; Friedrich, H.; de Jong, K.P.; de Jongh, P.E. Towards stable catalysts by controlling collective properties of supported metal nanoparticles. *Nature Materials* **2013**, *12*, 34-39, <https://doi.org/10.1038/nmat3471>.

164. Yang, W.; Zhang, L.; Wang, S.; White, A.D.; Jiang, S. Functionalizable and ultra stable nanoparticles coated with zwitterionic poly (carboxybetaine) in undiluted blood serum. *Biomaterials* **2009**, *30*, 5617-5621, <https://doi.org/10.1016/j.biomaterials.2009.06.036>.
165. Qi, J.; Yao, P.; He, F.; Yu, C.; Huang, C. Nanoparticles with dextran/chitosan shell and BSA/chitosan core—doxorubicin loading and delivery. *International journal of pharmaceutics* **2010**, *393*, 177-185.
166. Hauser, A.K.; Mathias, R.; Anderson, K.W.; Hilt, J.Z. The effects of synthesis method on the physical and chemical properties of dextran coated iron oxide nanoparticles. *Materials chemistry and physics* **2015**, *160*, 177-186, <https://doi.org/10.1016/j.matchemphys.2015.04.022>.
167. Ferreira Soares, D.C.; Domingues, S.C.; Viana, D.B.; Tebaldi, M.L. Polymer-hybrid nanoparticles: Current advances in biomedical applications. *Biomedicine & Pharmacotherapy* **2020**, *131*, 110695, <https://doi.org/10.1016/j.biopha.2020.110695>.
168. Friedrich, R.P.; Cicha, I.; Alexiou, C. Iron Oxide Nanoparticles in Regenerative Medicine and Tissue Engineering. *Nanomaterials* **2021**, *11*, 2337, <https://doi.org/10.3390/nano11092337>.
169. Ramimoghadam, D.; Bagheri, S.; Abd Hamid, S.B. Stable monodisperse nanomagnetic colloidal suspensions: An overview. *Colloids and Surfaces B: Biointerfaces* **2015**, *133*, 388-411, <https://doi.org/10.1016/j.colsurfb.2015.02.003>.
170. Sommertune, J.; Sugunan, A.; Ahniyaz, A.; Bejhed, R.S.; Sarwe, A.; Johansson, C.; Balceris, C.; Ludwig, F.; Posth, O.; Fornara, A. Polymer/iron oxide nanoparticle composites—a straight forward and scalable synthesis approach. *International journal of molecular sciences* **2015**, *16*, 19752-19768, <https://doi.org/10.3390/ijms160819752>.
171. Ali, A.; Hira Zafar, M.Z.; ul Haq, I.; Phull, A.R.; Ali, J.S.; Hussain, A. Synthesis, characterization, applications, and challenges of iron oxide nanoparticles. *Nanotechnology, science and applications* **2016**, *9*, 49, <https://doi.org/10.2147/NSA.S99986>.
172. Lo, S.; Fauzi, M.B. Current Update of Collagen Nanomaterials—Fabrication, Characterisation and Its Applications: A Review. *Pharmaceutics* **2021**, *13*, 316, <https://doi.org/10.3390/pharmaceutics13030316>.
173. Nagar, A.; Pradeep, T. Clean water through nanotechnology: Needs, gaps, and fulfillment. *ACS nano* **2020**, *14*, 6420-6435, <https://doi.org/10.1021/acsnano.9b01730>.
174. Saleh, T.A. Nanomaterials: Classification, properties, and environmental toxicities. *Environmental Technology & Innovation* **2020**, 101067, <https://doi.org/10.1016/j.eti.2020.101067>.
175. Maleki, A.; Kettiger, H.; Schoubben, A.; Rosenholm, J.M.; Ambrogi, V.; Hamidi, M. Mesoporous silica materials: From physico-chemical properties to enhanced dissolution of poorly water-soluble drugs. *Journal of Controlled Release* **2017**, *262*, 329-347, <https://doi.org/10.1016/j.jconrel.2017.07.047>.
176. Patil, S.S.; Shedbalkar, U.U.; Truskewycz, A.; Chopade, B.A.; Ball, A.S. Nanoparticles for environmental clean-up: a review of potential risks and emerging solutions. *Environmental Technology & Innovation* **2016**, *5*, 10-21, <https://doi.org/10.1016/j.eti.2015.11.001>.
177. Deshmukh, S.P.; Patil, S.M.; Mullani, S.B.; Delekar, S.D. Silver nanoparticles as an effective disinfectant: A review. *Materials Science and Engineering: C* **2019**, *97*, 954-965, <https://doi.org/10.1016/j.msec.2018.12.102>.
178. Thines, R.; Mubarak, N.; Nizamuddin, S.; Sahu, J.; Abdullah, E.; Ganesan, P. Application potential of carbon nanomaterials in water and wastewater treatment: a review. *Journal of the Taiwan Institute of Chemical Engineers* **2017**, *72*, 116-133, <https://doi.org/10.1016/j.jtice.2017.01.018>.
179. Rizzuto, C.; Pugliese, G.; Bahattab, M.A.; Aljlil, S.A.; Drioli, E.; Tocci, E. Multiwalled carbon nanotube membranes for water purification. *Separation and Purification Technology* **2018**, *193*, 378-385, <https://doi.org/10.1016/j.seppur.2017.10.025>.
180. Razmkhah, M.; Ahmadpour, A.; Mosavian, M.T.H.; Moosavi, F. What is the effect of carbon nanotube shape on desalination process? A simulation approach. *Desalination* **2017**, *407*, 103-115, <https://doi.org/10.1016/j.desal.2016.12.019>.
181. Kumar, V.; Katyal, D.; Nayak, S. Removal of heavy metals and radionuclides from water using nanomaterials: current scenario and future prospects. *Environmental Science and Pollution Research* **2020**, 1-26, <https://doi.org/10.1007/s11356-020-10348-4>.
182. Hua, M.; Zhang, S.; Pan, B.; Zhang, W.; Lv, L.; Zhang, Q. Heavy metal removal from water/wastewater by nanosized metal oxides: a review. *Journal of hazardous materials* **2012**, *211*, 317-331, <https://doi.org/10.1016/j.jhazmat.2011.10.016>.

183. Vishwakarma, V. Recovery and recycle of wastewater contaminated with heavy metals using adsorbents incorporated from waste resources and nanomaterials-A review. *Chemosphere* **2021**, 129677, <https://doi.org/10.1016/j.chemosphere.2021.129677>.
184. Fouda, A.; Salem, S.S.; Wassel, A.R.; Hamza, M.F.; Shaheen, T.I. Optimization of green biosynthesized visible light active CuO/ZnO nano-photocatalysts for the degradation of organic methylene blue dye. *Heliyon* **2020**, *6*, <https://doi.org/10.1016/j.heliyon.2020.e04896>.
185. Hlongwane, G.N.; Sekoai, P.T.; Meyyappan, M.; Moothi, K. Simultaneous removal of pollutants from water using nanoparticles: A shift from single pollutant control to multiple pollutant control. *Science of The Total Environment* **2019**, *656*, 808-833.
186. Siddiqui, S.I.; Chaudhry, S.A. Iron oxide and its modified forms as an adsorbent for arsenic removal: a comprehensive recent advancement. *Process Safety and Environmental Protection* **2017**, *111*, 592-626, <https://doi.org/10.1016/j.psep.2017.08.009>.
187. Vikrant, K.; Kim, K.-H.; Ok, Y.S.; Tsang, D.C.; Tsang, Y.F.; Giri, B.S.; Singh, R.S. Engineered/designer biochar for the removal of phosphate in water and wastewater. *Science of the Total Environment* **2018**, *616*, 1242-1260.
188. Hammad, E.N.; Salem, S.S.; Zohair, M.M.; Mohamed, A.A.; El-DougDoug, W. Purpureocillium lilacinum mediated biosynthesis copper oxide nanoparticles with promising removal of dyes. *Biointerface Research in Applied Chemistry* **2022**, *12*, 1397-1404, <https://doi.org/10.33263/BRIAC122.13971404>.
189. Mustapha, S.; Ndamitso, M.; Abdulkareem, A.; Tijani, J.; Shuaib, D.; Ajala, A.; Mohammed, A. Application of TiO₂ and ZnO nanoparticles immobilized on clay in wastewater treatment: a review. *Applied Water Science* **2020**, *10*, 1-36, <https://doi.org/10.1007/s13201-019-1138-y>.
190. Rambabu, K.; Bharath, G.; Banat, F.; Show, P.L. Green synthesis of zinc oxide nanoparticles using Phoenix dactylifera waste as bioreductant for effective dye degradation and antibacterial performance in wastewater treatment. *Journal of hazardous materials* **2021**, *402*, 123560, <https://doi.org/10.1016/j.jhazmat.2020.123560>.
191. Balusamy, B.; Senthamizhan, A.; Celebioglu, A.; Uyar, T. Single nozzle electrospinning promoted hierarchical shell wall structured zinc oxide hollow tubes for water remediation. *Journal of Colloid and Interface Science* **2021**, *593*, 162-171, <https://doi.org/10.1016/j.jcis.2021.02.089>.
192. Knight, A.W.; Ilani-Kashkouli, P.; Harvey, J.A.; Greathouse, J.A.; Ho, T.A.; Kabengi, N.; Ilgen, A.G. Interfacial reactions of Cu (ii) adsorption and hydrolysis driven by nano-scale confinement. *Environmental Science: Nano* **2020**, *7*, 68-80, <https://doi.org/10.1039/C9EN00855A>.
193. Dhiman, V.; Kondal, N. ZnO nanoadsorbents: a potent material for removal of heavy metal ions from wastewater. *Colloid and Interface Science Communications* **2021**, *41*, 100380, <https://doi.org/10.1016/j.colcom.2021.100380>.
194. Shaba, E.Y.; Jacob, J.O.; Tijani, J.O.; Suleiman, M.A.T. A critical review of synthesis parameters affecting the properties of zinc oxide nanoparticle and its application in wastewater treatment. *Applied Water Science* **2021**, *11*, 1-41, <https://doi.org/10.1007/s13201-021-01370-z>.
195. Sakr, M.A.; Sakthivel, K.; Hossain, T.; Shin, S.R.; Siddiqua, S.; Kim, J.; Kim, K. Recent trends in gelatin methacryloyl nanocomposite hydrogels for tissue engineering. *Journal of Biomedical Materials Research Part A* **2021**, <https://doi.org/10.1002/jbm.a.37310>.
196. Bustamante-Torres, M.; Romero-Fierro, D.; Arcentales-Vera, B.; Pardo, S.; Bucio, E. Interaction between filler and polymeric matrix in nanocomposites: Magnetic approach and applications. *Polymers* **2021**, *13*, 2998, <https://doi.org/10.3390/polym13172998>.
197. Cao, Y.; Chen, G.; Wan, Y.; Luo, J. Nanofiltration membrane for bio-separation: Process-oriented materials innovation. *Engineering in life sciences* **2021**, *21*, 405-416, <https://doi.org/10.1002/elsc.202000100>.
198. Bansal, P.; Sud, D. Polymeric TiO₂ Nanocomposites for Development of Fouling-Resistant Membranes for Wastewater Treatment. *Handbook of Nanomaterials and Nanocomposites for Energy and Environmental Applications* **2020**, 1-30.
199. Taufiq Musa, M.; Shaari, N.; Kamarudin, S.K. Carbon nanotube, graphene oxide and montmorillonite as conductive fillers in polymer electrolyte membrane for fuel cell: an overview. *International Journal of Energy Research* **2021**, *45*, 1309-1346, <https://doi.org/10.1002/er.5874>.
200. Mourad, R.; Darwesh, O.; Abdel-Hakim, A. Enhancing physico-mechanical and antibacterial properties of natural rubber using synthesized Ag-SiO₂ nanoparticles. *International Journal of Biological Macromolecules* **2020**, *164*, 3243-3249.

201. Azizi-Lalabadi, M.; Alizadeh-Sani, M.; Divband, B.; Ehsani, A.; McClements, D.J. Nanocomposite films consisting of functional nanoparticles (TiO₂ and ZnO) embedded in 4A-Zeolite and mixed polymer matrices (gelatin and polyvinyl alcohol). *Food Research International* **2020**, *137*, 109716.
202. Thakuria, A.; Kataria, B.; Gupta, D. Nanoparticle-based methodologies for targeted drug delivery—an insight. *Journal of Nanoparticle Research* **2021**, *23*, 1-30, <https://doi.org/10.1007/s11051-021-05190-9>.
203. Tenchov, R.; Bird, R.; Curtze, A.E.; Zhou, Q. Lipid nanoparticles—from liposomes to mRNA vaccine delivery, a landscape of research diversity and advancement. *ACS nano* **2021**, <https://doi.org/10.1021/acsnano.1c04996>.
204. Karki, N.; Rana, A.; Tiwari, H.; Negi, P.; Sahoo, N.G. Theranostics application of graphene-based materials in cancer imaging, targeting and treatment. In *Tumor Progression and Metastasis*; IntechOpen: **2020**, <https://doi.org/10.5772/intechopen.91331>.
205. Jayaraman, M.; Dutta, P.; Telang, J.; Krishnan BB, S. Nanoparticles for Cancer Therapy. In *Nanomedicine for Cancer Diagnosis and Therapy*; Springer: **2021**, 1-45, <https://doi.org/10.1515/ntrev-2013-0013>.
206. Gessner, I.; Neundorff, I. Nanoparticles modified with cell-penetrating peptides: Conjugation mechanisms, physicochemical properties, and application in cancer diagnosis and therapy. *International journal of molecular sciences* **2020**, *21*, 2536, <https://doi.org/10.3390/ijms21072536>.
207. Yang, B.; Wang, T.-t.; Yang, Y.-s.; Zhu, H.-l.; Li, J.-h. The application progress of peptides in drug delivery systems in the past decade. *Journal of Drug Delivery Science and Technology* **2021**, 102880.
208. Zhang, T.; Xu, Q.; Huang, T.; Ling, D.; Gao, J. New Insights into Biocompatible Iron Oxide Nanoparticles: A Potential Booster of Gene Delivery to Stem Cells. *Small* **2020**, *16*, 2001588, <https://doi.org/10.1002/smll.202001588>.
209. Salimi, M.; Sarkar, S.; Hashemi, M.; Saber, R. Treatment of Breast Cancer-Bearing BALB/c Mice with Magnetic Hyperthermia using Dendrimer Functionalized Iron-Oxide Nanoparticles. *Nanomaterials* **2020**, *10*, 2310, <https://doi.org/10.3390/nano10112310>.
210. Kumar, S.N.; James, V.; James, V.; Maheswari, M.A.; Sivaraman, N.; Rao, C.B.; Prabhakaran, D. New age monolithic design-based visible light responsive and reusable photocatalyst material using iron oxide-modified mesoporous titania framework. *Bulletin of Materials Science* **2020**, *43*, 1-14, <https://doi.org/10.1021/am301394u>.
211. Zhou, H.; Mayorga-Martinez, C.C.; Pané, S.; Zhang, L.; Pumera, M. Magnetically driven micro and nanorobots. *Chemical Reviews* **2021**, *121*, 4999-5041, <https://doi.org/10.1021/acs.chemrev.0c01234>.
212. Sung, B.; Kim, M.H.; Abelman, L. Magnetic microgels and nanogels: Physical mechanisms and biomedical applications. *Bioengineering & translational medicine* **2021**, *6*, e10190.
213. Bi, Q.; Song, X.; Hu, A.; Luo, T.; Jin, R.; Ai, H.; Nie, Y. Magnetofection: Magic magnetic nanoparticles for efficient gene delivery. *Chinese Chemical Letters* **2020**, *31*, 3041-3046, <https://doi.org/10.1016/j.ccllet.2020.07.030>.
214. Zeinali, M.; Abbaspour-Ravasjani, S.; Ghorbani, M.; Babazadeh, A.; Soltanfam, T.; Santos, A.C.; Hamishehkar, H.; Hamblin, M.R. Nanovehicles for co-delivery of anticancer agents. *Drug Discovery Today* **2020**, <https://doi.org/10.1016/j.drudis.2020.06.027>.
215. Abdollahiyan, P.; Oroojalian, F.; Hejazi, M.; de la Guardia, M.; Mokhtarzadeh, A. Nanotechnology, and scaffold implantation for the effective repair of injured organs: An overview on hard tissue engineering. *Journal of Controlled Release* **2021**.
216. Amiriyaghoubi, N.; Fathi, M.; Barzegari, A.; Barar, J.; Omidian, H.; Omid, Y. Recent advances in polymeric scaffolds containing carbon nanotube and graphene oxide for cartilage and bone regeneration. *Materials Today Communications* **2021**, 102097, <https://doi.org/10.1016/J.MTCOMM.2021.102097>.
217. Patel, S.J.; Wellington, M.; Shah, R.M.; Ferreira, M.J. Antibiotic Stewardship in Food-producing Animals: Challenges, Progress, and Opportunities. *Clinical Therapeutics* **2020**, *42*, 1649-1658, <https://doi.org/10.1016/j.clinthera.2020.07.004>.
218. Varela, M.F.; Stephen, J.; Lekshmi, M.; Ojha, M.; Wenzel, N.; Sanford, L.M.; Hernandez, A.J.; Parvathi, A.; Kumar, S.H. Bacterial Resistance to Antimicrobial Agents. *Antibiotics* **2021**, *10*, 593.
219. Erkoc, P.; Ulucan-Karnak, F. Nanotechnology-Based Antimicrobial and Antiviral Surface Coating Strategies. *Prosthesis* **2021**, *3*, 25-52, <https://doi.org/10.3390/prosthesis3010005>.
220. Jana, S.K.; Gucchait, A.; Paul, S.; Saha, T.; Acharya, S.; Hoque, K.M.; Misra, A.K.; Chatterjee, B.K.; Chatterjee, T.; Chakrabarti, P. Virstatin-Conjugated Gold Nanoparticle with Enhanced Antimicrobial Activity against the *Vibrio cholerae* El Tor Biotype. *ACS Applied Bio Materials* **2021**, *4*, 3089-3100, <https://doi.org/10.1021/acsbm.0c01483>.

221. Singh, R.K.; Behera, S.S.; Singh, K.R.; Mishra, S.; Panigrahi, B.; Sahoo, T.R.; Parhi, P.K.; Mandal, D. Biosynthesized gold nanoparticles as photocatalysts for selective degradation of cationic dye and their antimicrobial activity. *Journal of Photochemistry and Photobiology A: Chemistry* **2020**, *400*, 112704, <https://doi.org/10.1016/j.jphotochem.2020.112704>.
222. Saied, E.; Eid, A.M.; Hassan, S.E.D.; Salem, S.S.; Radwan, A.A.; Halawa, M.; Saleh, F.M.; Saad, H.A.; Saied, E.M.; Fouda, A. The catalytic activity of biosynthesized magnesium oxide nanoparticles (Mgo-nps) for inhibiting the growth of pathogenic microbes, tanning effluent treatment, and chromium ion removal. *Catalysts* **2021**, *11*, <https://doi.org/10.3390/catal11070821>.
223. Hashem, A.H.; Salem, S.S. Green and ecofriendly biosynthesis of selenium nanoparticles using *Urtica dioica* (Stinging nettle) leaf extract: Antimicrobial and anticancer activity. *Biotechnology Journal n/a*, 2100432, <https://doi.org/10.1002/biot.202100432>.
224. Abu-Elghait, M.; Hasanin, M.; Hashem, A.H.; Salem, S.S. Ecofriendly novel synthesis of tertiary composite based on cellulose and myco-synthesized selenium nanoparticles: Characterization, antibiofilm and biocompatibility. *International Journal of Biological Macromolecules* **2021**, *175*, 294-303, <https://doi.org/10.1016/j.ijbiomac.2021.02.040>.
225. Mohamed, A.A.; Abu-Elghait, M.; Ahmed, N.E.; Salem, S.S. Eco-friendly Mycogenic Synthesis of ZnO and CuO Nanoparticles for *In vitro* Antibacterial, Antibiofilm, and Antifungal Applications. *Biological Trace Element Research* **2021**, *199*, 2788-2799, <https://doi.org/10.1007/s12011-020-02369-4>.
226. Hassan, S.E.L.D.; Salem, S.S.; Fouda, A.; Awad, M.A.; El-Gamal, M.S.; Abdo, A.M. New approach for antimicrobial activity and bio-control of various pathogens by biosynthesized copper nanoparticles using endophytic actinomycetes. *Journal of Radiation Research and Applied Sciences* **2018**, *11*, 262-270, <https://doi.org/10.1016/j.jrras.2018.05.003>.
227. Hashem, A.H.; Salem, S.S. Green and ecofriendly biosynthesis of selenium nanoparticles using *Urtica dioica* (stinging nettle) leaf extract: Antimicrobial and anticancer activity. *Biotechnology Journal* **2021**, <https://doi.org/10.1002/biot.202100432>.
228. Aref, M.S.; Salem, S.S. Bio-callus synthesis of silver nanoparticles, characterization, and antibacterial activities via *Cinnamomum camphora* callus culture. *Biocatalysis and Agricultural Biotechnology* **2020**, *27*, <https://doi.org/10.1016/j.bcab.2020.101689>.
229. Elsayy, M.M.; Faheim, A.A.; Salem, S.S.; Owda, M.E.; Abd El-Wahab, Z.H.; Abd El-Wahab, H. Cu (II), Zn (II), and Ce (III) metal complexes as antimicrobial pigments for surface coating and flexographic ink. *Applied Organometallic Chemistry* **2021**, *35*, <https://doi.org/10.1002/aoc.6196>.
230. Salem, S.S. Bio-fabrication of Selenium Nanoparticles Using Baker's Yeast Extract and Its Antimicrobial Efficacy on Food Borne Pathogens. *Applied Biochemistry and Biotechnology* **2022**, <https://doi.org/10.1007/s12010-022-03809-8>.
231. Younis, S.A.; Maitlo, H.A.; Lee, J.; Kim, K.-H. Nanotechnology-based sorption and membrane technologies for the treatment of petroleum-based pollutants in natural ecosystems and wastewater streams. *Advances in colloid and interface science* **2020**, *275*, 102071, <https://doi.org/10.1016/j.cis.2019.102071>.
232. Jain, K.; Patel, A.S.; Pardhi, V.P.; Flora, S.J.S. Nanotechnology in Wastewater Management: A New Paradigm Towards Wastewater Treatment. *Molecules* **2021**, *26*, 1797, <https://doi.org/10.3390/molecules26061797>.
233. Yang, X.; Zhao, Z.; Yu, Y.; Shimizu, K.; Zhang, Z.; Lei, Z.; Lee, D.-J. Enhanced biosorption of Cr (VI) from synthetic wastewater using algal-bacterial aerobic granular sludge: Batch experiments, kinetics and mechanisms. *Separation and Purification Technology* **2020**, *251*, 117323, <https://doi.org/10.1016/j.seppur.2020.117323>.
234. Cheriyaundath, S.; Vavilala, S.L. Nanotechnology-based wastewater treatment. *Water and Environment Journal* **2021**, *35*, 123-132, <https://doi.org/10.1111/wej.12610>.
235. Eid, A.M.; Fouda, A.; Abdel-rahman, M.A.; Salem, S.S.; Elsaied, A.; Oelmüller, R.; Hijri, M.; Bhowmik, A.; Elkelish, A.; El-Din Hassan, S. Harnessing bacterial endophytes for promotion of plant growth and biotechnological applications: An overview. *Plants* **2021**, *10*, <https://doi.org/10.3390/plants10050935>.
236. Hofmann, T.; Lowry, G.V.; Ghoshal, S.; Tufenkji, N.; Brambilla, D.; Dutcher, J.R.; Gilbertson, L.M.; Giraldo, J.P.; Kinsella, J.M.; Landry, M.P.; *et al.* Technology readiness and overcoming barriers to sustainably implement nanotechnology-enabled plant agriculture. *Nature Food* **2020**, *1*, 416-425, <https://doi.org/10.1038/s43016-020-0110-1>.

237. Pramanik, P.; Krishnan, P.; Maity, A.; Mridha, N.; Mukherjee, A.; Rai, V. Application of Nanotechnology in Agriculture. In *Environmental Nanotechnology Volume 4*, Dasgupta, N., Ranjan, S., Lichtfouse, E., Eds.; Springer International Publishing: Cham, **2020**, 317-348.
238. Salama, D.M.; Abd El-Aziz, M.E.; Rizk, F.A.; Abd Elwahed, M.S.A. Applications of nanotechnology on vegetable crops. *Chemosphere* **2021**, *266*, 129026, <https://doi.org/10.1016/j.chemosphere.2020.129026>.
239. Alghuthaymi, M.A.; Ahmad, A.; Khan, Z.; Khan, S.H.; Ahmed, F.K.; Faiz, S.; Nepovimova, E.; Kuča, K.; Abd-Elsalam, K.A. Exosome/Liposome-like Nanoparticles: New Carriers for CRISPR Genome Editing in Plants. *International Journal of Molecular Sciences* **2021**, *22*, 7456, <https://doi.org/10.3390/ijms22147456>.
240. Kalita, R.; Saha, O.; Rahman, N.; Tiwari, S.; Phukon, M. Nanotechnology in Agriculture. In *Nanobiotechnology : Mitigation of Abiotic Stress in Plants*, Al-Khayri, J.M., Ansari, M.I., Singh, A.K., Eds.; Springer International Publishing: Cham, **2021**, 101-116.
241. Badawy, A.A.; Abdelfattah, N.A.H.; Salem, S.S.; Awad, M.F.; Fouda, A. Efficacy assessment of biosynthesized copper oxide nanoparticles (CuO-nps) on stored grain insects and their impacts on morphological and physiological traits of wheat (*triticum aestivum* L.) plant. *Biology* **2021**, *10*, <https://doi.org/10.3390/biology10030233>.
242. Abdelaziz, A.M.; Dacrory, S.; Hashem, A.H.; Attia, M.S.; Hasanin, M.; Fouda, H.M.; Kamel, S.; ElSaied, H. Protective role of zinc oxide nanoparticles based hydrogel against wilt disease of pepper plant. *Biocatalysis and Agricultural Biotechnology* **2021**, *35*, 102083, <https://doi.org/10.1016/j.bcab.2021.102083>.
243. Hasanin, M.; Hashem, A.H.; Lashin, I.; Hassan, S.A.M. *In vitro* improvement and rooting of banana plantlets using antifungal nanocomposite based on myco-synthesized copper oxide nanoparticles and starch. *Biomass Conversion and Biorefinery* **2021**, <https://doi.org/10.1007/s13399-021-01784-4>.
244. Goswami, A.; Roy, I.; Sengupta, S.; Debnath, N. Novel applications of solid and liquid formulations of nanoparticles against insect pests and pathogens. *Thin Solid Films* **2010**, *519*, 1252-1257, <https://doi.org/10.1016/j.tsf.2010.08.079>.
245. Christopher, F.C.; Kumar, P.S.; Christopher, F.J.; Joshiba, G.J.; Madhesh, P. Recent advancements in rapid analysis of pesticides using nano biosensors: A present and future perspective. *Journal of Cleaner Production* **2020**, *269*, 122356, <https://doi.org/10.1016/j.jclepro.2020.122356>.