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Review Article

Extracellular Algae based Nanoparticles, Overview, Mechanisms and some Medical Applications

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Abstract: Algae and their metabolites are possessing variety of properties that enhance different medical, industrial and environmental fields. These organisms are distributed in nature and adapt to variety circumstances. Nanotechnology is a fast developmental scientific field that a huge number of researches have globally published in order to cover its applications and provide recent findings of this significantly important field. This paper display back ground on nanotechnology, definition and historical overview, as well as different techniques involving the use of algae to facilitate the production of nano materials. Focusing on three groups; brown(phaeophyta), red (rhodophyta) and blue green algae (cyanophyta) and their extracellular metabolites. In addition, several medical applications of algae based nanomaterials is discussed. Including the use of these nano-sized particles against bacteria, virus, biofilm producing microbes and bio sensing technique.

Keywords: Nanoparticles, Nanotechnology, Medical Application.

Definition of Nanotechnology

Some individual molecules are excluded from the term "nanoparticle" and is primarily utilized to describe inorganic materials. during the 1970s and 1980s, the "Nanoparticle" were used as interchangeable terms due to some fundamental researching were proceeding in the us and Japan by Granqvist and Buhrman, thus were given the term ultra-fine particle" Prior to the commencement of the National Nanotechnology Initiative in the United States, the term "nanoparticle" had gained widespread usage in the 1990s. Nanoparticles can have distinct features that are markedly different from both fine particles and bulk materials due to their size. Despite being commonly linked with current science, nanoparticles have a lengthy historical background [Chaudhary *et al.*, 2020]

The scientific significance of "nanoparticles" lies in their ability to serve as a connection between bulk materials and atomic or molecular structures. At the macroscopic scale, a bulk material exhibits consistent physical characteristics regardless of its size. However, at the nanoscale, the material's qualities become dependent on its size. The large surface area of nanoparticles is what gives them their interesting and surprising qualities. This is more important than the small mass of the materials. Solar cells, for instance, absorb more sunlight through substance made up of nanoparticles than through thin films of continuous sheets of material.

The size, shape, and material of the particles can be changed to control how much sunlight is absorbed. Titanium dioxide nanoparticles known as have ability to clean themselves, and due to the particles are nanosized, they cannot be heeded. Zinc oxide nanoparticles has the capability to effectively block ultraviolet radiation in comparison to their larger counterparts. This, together with their photo stability, is a key factor in their frequent use in the production of sunscreen creams. When clay nanoparticles are combined with polymer matrices, they enhance reinforcing, resulting in stronger plastics. This is evident via a higher glass transition temperature and other technical characteristics.

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The clay nanoparticles possess a high level of hardness and transfer their characteristics to the polymer. [Koo, 2006]. The rapid development witnessed in the past decades in the specialization of nanotechnology is because of to the exceptional physical and chemical properties of nanoparticles and the nanomaterials correlation with them. The intervention of nanotechnology in all disciplines of science is one of the reasons for the creation of new alternatives aimed at solving various bottlenecks related to research. Nanobiotechnology originated from the creation of nanoscale particles using biological components that may impact the physical properties of nanoparticles. The production of nanoparticles (NPs) with various sizes and shapes has generated significant attention because of their unique features in comparison to larger forms. The nanoscale exhibits significant variations in the chemical, biological, and physicochemical characteristics of materials mostly because of the substantial ratio between surface area and volume. These variation lead to substantial discrepancies.

The mechanical properties, melting point, optical absorption, thermal conductivity, electrical conductivity, and biological traits are all factors related to the physical characteristics of a material. Electrical conductivity, biological functions, and catalytic capacities. Nanoparticles (NPs) serve as a connection between the overall and catalytic functions. Nanoparticles (NPs) serve as a connection between materials in large quantities and atomic or molecular structures. Nanoparticles (NPs) typically vary in size between 1 and 100 nm and have been categorized based on their origin, dimensions, and structural configurations [Tomas *et al*., 2023].

Techniques for Producing Metal Nanoparticles

Different techniques have been produced to generate metal nanoparticles. Two synthesis methods have been found, which are top-down and bottom-up. The first process is from top to bottom, represented by grinding, lithography, and repeated cooling. This method is poor in terms of precise control of particle size and structure. The second channel, from bottom to top, is the chosen method used to synthesize nanoparticles. This process entails building the material by starting to build its basic components and building them gradually [Adlim, 2006; Fairai *et al*., 2021]

In general, there are three main methods to synthesize metal nanoparticles:

A. Chemical methods.
B. Physical methods.
C. Biological method

Green nanomaterials are the result of combining green nanotechnology and green chemistry. They possess distinct features depending on their structure and are environmental friendly [Arif *et al*., 2024]. The plant extract consists of active components such as the compounds present are terpenoids, alkaloids, phenols, tannins, and vitamins. These compounds serve as capping and reducing agents. The size, form, and applications of nanoparticles (NPs) are determined by the source from which they are produced [Qamar and Ahmed, 2021]. In this research, the writers specifically focused on the biological technique and algal-based synthesis.

Synthesis of Nano Particles Using Algae

Algae are increasingly being utilized for green synthesis since they possess a large quantity of proteins, peptides, pigments and other secondary metabolites. Thus, they serve as nano-biofactories, in addition, they exhibit rapid growth, can be easily harvested, and are cost-efficient to scale up, making them advantageous.

Algae have been extensively used for commercial and industrial purposes such as food, feed, additives, and as potential candidates for the biological production of nanoparticles. Algae are the most rudimentary creatures found in cosmetics, medicines, fertilizers, and bioremediation agents. The justification for using a variety of habitats and prevailing photosynthetic organisms on our planet. Algae have the capability of performing green synthesis without the need for external reducing or capping agents. They need little energy to gather metals and convert them into nanoparticles, which makes them an excellent option for environmentally friendly production, cost-effective synthesis, and straightforward reactions. [Fawcett *et al*., 2017; Singh *et al*., 2024].

Algae easily found in nature, are not poisonous, and have the ability to generate several kinds of metal oxide nanoparticles. This method has the potential to greatly speed up the creation of new algae-nanomaterials that have enhanced characteristics and performance. [Alprol *et al*., 2023]. There are two primary methods for synthesizing nanoparticles using algae. The first involves directly using live algae cells to synthesize nanoparticles. The second method involves breaking down algal cells and extracting the nanoparticles using techniques such as centrifugation, filtration, and harvesting from the liquid portion of the algal broth.

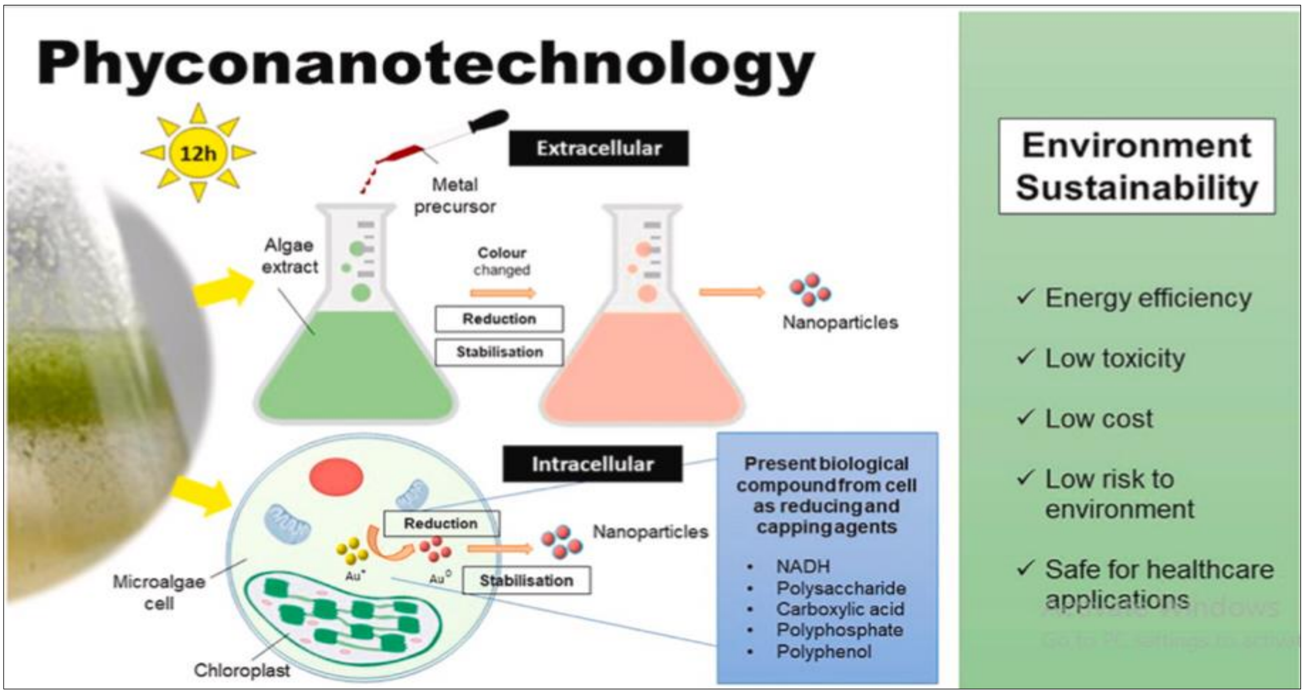

Figure 1: extracellular and intracellular algae based nanotechnology [Chan *et al.*, 2022]

According to Mukherjee *et al*., (2011), the production of metal nanoparticles using algae typically involves the following fundamental steps:

1. Applying heat or bringing an algal extract to its boiling point in either water or an organic solution for a predetermined duration.
2. Creating ionic metallic compound molar solutions.
3. For a specific amount of time, both the algae and the solutions of ionic metallic compounds are incubated in controlled environments with or without regular stirring.

That being said, using algae to make nanoparticles is a well-known area of nanosynthesis. The field of phyco-nanotechnology, which makes metallic and metal oxide nanoparticles from different kinds of algae, is still in its early stages of growth. Now, this review will look at the possibilities of blue-green algae (Cyanophyceae), red algae (Rhodophyceae), and brown algae (Phaeophyceae). Brown algae are classified within the taxonomic order Fucales and the family Sargassaceae. Fucales are predominantly composed of sterols, such as cholesterols and fucosterols, together with sulfated polysaccharides.

In addition, they possess functional groups such as glucuronic acid, muramic acid, alginic acid, and vinyl derivatives. These components function as both reducing agents and capping agents in the synthesis of nanoparticles [Kumar *et al.*, 2011]. Red algae, belonging to the family Rhodophyta, are mostly eaten as food in many places because they have a unique taste and are high in proteins and vitamins that our bodies need. It is very easy for these vitamins and proteins to keep the size of nanoparticles the same or smaller while algae help with production. But research into making nanoparticles from red algae found in seaweed is still in its early stages. This is because they have problems with self-assembly, slow crystallisation growth, and stability [Singh *et al.*, 2013]

The blue green algae distinct that belong to order chroococcales order has a special situation in the biology especially two family Entophysalidaceae and Chroococcaceae distinguished by their growth which live in colony. This type of algae growing as masses that found on wet rocks. Blue green algae distinguished that is photoautotrophic, which is utilize water as a donor of electron and it is contain two type of photo - pigment which is chlorophyll A and carotene, that is help in doing photosynthesis. They are regarded as equivalents of unicellular bacteria due to their similar shape. Blue-green algae have been extensively utilized for the production of various nanoparticles, in contrast to brown and red algae [Mosulishvili *et al.*, 2007].

Table 1: Extracellular mediated biosynthesis of metallic NPs using algae [Chaudhary *et al.*, 2020]

Algae	NPs	Location	Reducing Agent
Brown algae			
Turbinaria conoides	Ag	Extracellular	Carbonylgroups and Polyamines
Fucus vesiculosus	Au	Extracellular	Hydroxyl, amine functional groups
Sargassum polycystum	Ag	Extracellular	Hydroxyl groups Present In polysaccharides
Laminaria japonica	Au	Extracellular	Polysaccharides
Red algae			
Gracilaria edulis	Ag	Extracellular	Proteins and terpenoids
Chondrus crispus	Au	Extracellular	Proteins
Gracilaria dura	Ag	Extracellular	Polymers
Kappa phycus	Au	Extracellular	——————
Blue-green algae			
Nostoc ellipsosporum	Au	Extracellular	Proteins and carboxylate groups
Spirulina platenesis	Au	Extracellular	Proteins
Phormidium sp.	Au	Extracellular	Cytoplasmic proteins
Anabaena sp.	Au	Extracellular	Protein moieties

Biomedical Uses of Algae-Facilitated Nanoparticles

In this section, several biomedical applications of algae based nanoparticles have displayed. Nanoparticles can attach and pass through the glycoprotein of the viral surface, this leads to inhibition of viral genome multiplication and block the RNA action. Another antiviral mechanism of nanoparticles is agglutination due to adhesion of these particles with viral surface glycoprotein, leading to block the viral binding to host cells and inhibits their passage into the cell (Gurunathan *et al*., 2020). The brown alga *Sargassum wightii* mediated gold and silver nanoparticles were recorded as an antiviral agent against HSV. Another study suggested that *Oscillatoria* sp. mediated Silver nanoparticles *Spirulina platensis* mediated Gold NPs exhibited antiviral potentiality against HSV (Mostafa *et al*., 2022).

Antibiotic resistance has emerged as a consequence of the widespread use of these medications to treat bacterial infections. It is critical to find a safe and effective way to treat drug-resistant germs since they are a major threat to global health. Consequently, nanoparticles have replaced conventional antibacterial agents due to their better efficacy in killing microorganisms. Because NPs kill bacteria by disrupting cell membranes, they are a powerful antimicrobial tool. [Wang *et al*., 2017] A study of (Mandal *et al*., 2023) reported that algae based nanoparticles are more effective on bacteria than physically and chemically synthesized metallic nanoparticles. The disruption of the cell wall by silver nanoparticles in gram-negative bacteria results to genomic instability, while they degrade the peptidoglycan in gram-positive bacteria.

Silver nanoparticles that were synthesized from the brown alga *Padina tetrastromatica* exhibited effective inhibition of the growth of many bacterial genera including *Bacillus subtilis, Klebsiellaplanticola*, and *Pseudomonas aeruginosa*. In addition, a significant growth inhibition was observed after using spherical gold nanoparticles prepared with protein extracted from Spirulina platensis on both *Bacillus subtilis* and *Staphylococcus aureus* (Behera *et al*., 2023).

Bacteria primarily occur as biofilms, which consist of a variety of species including fungi and algae. These species engage in social interactions with one another and their respective surroundings. The presence of unwanted organisms on submerged surfaces is commonly referred to as biofouling. This phenomenon presents substantial health hazards and financial setbacks in the marine, medical, and industrial sectors. Antifouling procedures encompass a variety of techniques, including the application of biocides and the use of toxic chemicals. However, these treatments have the unintended consequence of collecting and polluting the environment. Consequently, nanoparticles (NPs) have been studied as potential substitutes for antifouling chemicals due to their ability to efficiently prevent bacterial attachment by interacting with ligands on NPs and inhibiting biofilm formation on surfaces [Bixler, 2012]. In bio sensing field, algal-synthesized gold nanoparticles exhibit excellent optical characteristics that can be effectively employed in biosensing applications. These applications include the detection of hormones in the human body, which is particularly valuable in cancer diagnosis [Elgamouz *et al.*, 2020]. This review gives a general insight on algae mediated nano applications and provide several findings supplying the extensively growing fields of nanotechnology.

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REFERENCE

- Adlim A. (2006). Review: Preparations and application of metal nanoparticles. *Indonesian Journal of Chemistry, 6*(1), 1-10. https://doi.org/10.22146/ijc.21785
- Alprol, A. E., Mansour, A. T., Abdelwahab, A. M., & Ashour, M. (2023). Advances in green synthesis of metal oxide nanoparticles by marine algae for wastewater treatment by adsorption and photocatalysis techniques. *Catalysts*, *13*(5), 888.
- Amutha, V., Deepak, P., Kamaraj, C., Balasubramani, G., Aiswarya, D., Arul, D., ... & Perumal, P. (2019). Mosquito-larvicidal potential of metal and oxide nanoparticles synthesized from aqueous extract of the seagrass, Cymodocea serrulata. *Journal of Cluster Science, 30,* 797-812.
- Arif, M. D., Hoque, M. E., Rahman, M. Z., & Shafoyat, M. U. (2024). Emerging Directions in Green Nanomaterials: Synthesis, Physicochemical Properties and Applications. *Materials Today Communications*, 109335.
- Behera, M., Behera, P. R., Bhuyan, P. P., Singh, L., & Pradhan, B. (2023). Algal nanoparticles and their antibacterial activity: current research status and future prospectives. *Drugs and Drug Candidates*, *2*(3), 554-570.
- Biswal, J. (2012). A Study on Synthesis of Silver and Gold Nanoparticles by Employing Gamma Radiation, Their Characterization and Applications. Homi Bhabha National Institute; *Department of Chemical Sciences*. Available from: http://hdl.handle.net/10603/11458
- Bixler, G. D., & Bhushan, B. (2012). Review article: Biofouling: Lessons from nature. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *370*(1967), 2381–2417. https://doi.org/10.1098/rsta.2011.0502
- Chan, S. S., kit, S. L., & Chewcd, W. Prospects and environmental sustainability of phyconanotechnology: A review on algae-mediated metal nanoparticles synthesis and mechanism https://doi.org/10.1016/j.envres.2022.113140
- Chaudhary, R. (2020). An Overview of the Algae-Mediated Biosynthesis of Nanoparticles and Their Biomedical Applications. *Biomolecules, 10,* 1498. doi:10.3390/biom10111498
- Chaudhary, R., Nawaz, K., Khan, A. K., Hano, C., Abbasi, B. H., & Anjum, S. (2020). An overview of the algae-mediated biosynthesis of nanoparticles and their biomedical applications. *Biomolecules*, *10*(11), 1498.
- D'Amato, R., Falconieri, M., Gagliardi, S., Popovici, E., Serra, E., Terranova, G., & Borsella, E. (2013). Synthesis of ceramic nanoparticles by laser pyrolysis: from research to applications. *Journal of analytical and applied pyrolysis*, *104*, 461-469.
- Elgamouz, A., Idriss, H., Nassab, C., Bihi, A., Bajou, K., Hasan, K., ... & Patole, S. P. (2020). Green synthesis, characterization, antimicrobial, anti-cancer, and optimization of colorimetric sensing of hydrogen peroxide of algae extract capped silver nanoparticles. *Nanomaterials*, *10*(9), 1861.
- Farirai, F., Ozonoh, M., Aniokete, T. C., Eterigho-Ikelegbe, O., Mupa, M., Zeyi, B., & Daramola, M. O. (2021). Methods of extracting silica and silicon from agricultural waste ashes and application of the produced silicon in solar cells: a mini-review. *International Journal of Sustainable Engineering*, *14*(1), 57-78.
- Fawcett, D., Verduin, J. J., Shah, M., Sharma, S. B., & Poinern, G. E. J. (2017). A review of current research into the biogenic synthesis of metal and metal oxide nanoparticles via marine algae and seagrasses. *Journal of Nanoscience*, *2017*(1), 8013850.
- Gurunathan, S., Qasim, M., Choi, Y., Do, J. T., Park, C., Hong, K., ... & Song, H. (2020). Antiviral potential of nanoparticles—can nanoparticles fight against coronaviruses?. *Nanomaterials*, *10*(9), 1645.
- González-Ballesteros, N., Rodríguez-Argüelles, M. C., Lastra-Valdor, M., González-Mediero, G., Rey-Cao, S., Grimaldi, M., ... & Bigi, F. (2020). Synthesis of silver and gold nanoparticles by Sargassum muticum biomolecules and evaluation of their antioxidant activity and antibacterial properties. *Journal of Nanostructure in Chemistry, 10,* 317-330.
- Koo, J. H. (2006). PolymerNanocomposites,TheMcGrawHillsCompanies,NewYork, 2–4 ISBN 978-0-07-149204-1
- Kumar, S. S., Kumar, Y., Khan, M. S. Y., Anbu, J., & De Clercq, E. (2011). Antihistaminic and antiviral activities of steroids of Turbinaria conoides. *Natural Product Research*, *25*(7), 723-729.
- Mandal, A. S., Bhattacharyya, K., Totad, R. D., & Raj, H. J. (2023). *O R I G I N A L A R T I C L E Anti-biofilm role of silver nanoparticles on microbial biofilm: An in vitro study on biofilm of heart valves*. *6*, 223–232.ISSN 0974-1143
- El-Sheekh, M. M., Morsi, H. H., Hassan, L. H., & Ali, S. S. (2022). The efficient role of algae as green factories for nanotechnology and their vital applications. *Microbiological Research*, *263*, 127111.
- Mosulishvili, L. M., Belokobylsky, A. I., Kirkesali, E. I., Frontasyeva, M. V., Pavlov, S. S., & Aksenova, N. G. (2007). Neutron activation analysis for studying Cr uptake in the blue-green microalga Spirulina platensis. *Journal of Neutron Research*, *15*(1), 49-54.
- Mukherjee, A., Sarkar, D., & Sasmal, S. (2021). A review of green synthesis of metal nanoparticles using algae. *Frontiers in Microbiology*, *12*, 693899.
- Qamar, S. U. R., & Ahmad, J. N. (2021). Nanoparticles: Mechanism of biosynthesis using plant extracts, bacteria, fungi, and their applications. *Journal of Molecular Liquids*, *334*, 116040.

- Singh, M., Kalaivani, R., Manikandan, S., Sangeetha, N., & Kumaraguru, A. K. (2013). Facile green synthesis of variable metallic gold nanoparticle using Padina gymnospora, a brown marine macroalga. *Applied Nanoscience*, *3*, 145-151.
- Singh, S. K., Sharma, A., Sharma, L., & Sundaram, S. (2024). Green Synthesis of Algal Nanoparticles: Harnessing Nature's Biofactories for Sustainable Nanomaterials. In *Biogenic Wastes-Enabled Nanomaterial Synthesis: Applications in Environmental Sustainability* (pp. 257-284). Cham: Springer Nature Switzerland.
- Tomás, H., & Rodrigues, J. (2023). Dendrimers and dendrimer-based nano-objects for oncology applications. In *New Trends in Smart Nanostructured Biomaterials in Health Sciences* (pp. 41-78). Elsevier.
- Wang, L., Hu, C., & Shao, L. (2017). The antimicrobial activity of nanoparticles: present situation and prospects for the future. *International journal of nanomedicine*, 1227-1249.