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SHORT ARTICLE

Metallic Nanoparticles Applications in Medicine

Yavvari Anusha Rani, M Nagalakshmi Devamma*

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Abstract

Metallic nanoparticles (MNPs) are revolutionizing the field of medicine with their unique properties and diverse applications. From targeted drug delivery and photothermal therapy to bioimaging and biosensing, MNPs hold immense potential to improve diagnosis, treatment, and disease monitoring. This review explores the current state of MNP research in medicine, highlighting their diverse applications, advantages, and challenges.

Key Words: *Metallic nanoparticles; Treatment; Diagnosis; Therapeutics*

Introduction

Metallic nanoparticles, or MNPs, are minuscule particles that have the capacity to completely transform the medical industry. Because of their compact size, high surface area, and special qualities, MNPs have intriguing opportunities for applications in a range of fields (Figure 1) [1].

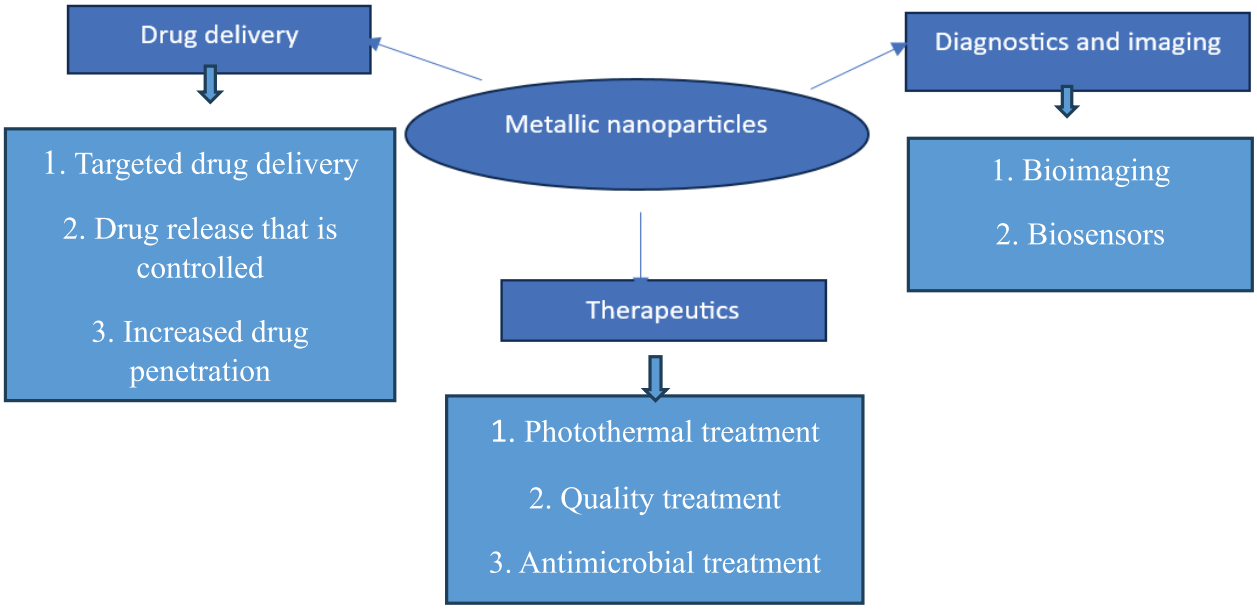

Figure 1) *Importance of metallic nanoparticles.*

Department of Botany, Sri Venkateswara University, Tirupati, India

Corresponding author: M Nagalakshmi Devamma, Associate Professor, Department of Botany, Sri Venkateswara University, Tirupati, India, Tel: 91-7569242750; E-mail: nagalakshmidevamma156@gmail.com

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Drug delivery

- Targeted drug delivery: MNPs can be engineered to target sick cells in particular, minimizing negative effects and enhancing medication effectiveness. By adding targeting ligands to the MNPs' surface, which bind to particular receptors on the target cells, this can be accomplished [2]. Drug release that is controlled: MNPs have the ability to release medications gradually over time, which can increase patient compliance and lessen the need for regular dosage [3].
- Increased drug penetration: MNPs can facilitate a drug's deeper tissue absorption, increasing its efficacy against specific illnesses [4].

Diagnostics and imaging

- Bio imaging: MNPs can be utilized to make contrast specialists for different imaging modalities, for example, attractive reverberation imaging (X-ray), figured tomography (CT), and positron discharge tomography (PET). This considers further developed representation of tissues and organs, supporting determination and infection checking [5].
- Biosensors: MNPs can be utilized as biosensors to identify explicit biomarkers of sickness, like malignant growth or irresistible illnesses. This considers early finding and treatment of these diseases [6].

Therapeutics

- Photothermal treatment: MNPs can be utilized to warm growths upon openness to light, prompting growth cell passing. This is an insignificantly obtrusive therapy choice for certain sorts of disease [7].
- Quality treatment: MNPs can be utilized to convey qualities to explicit cells, which might treat hereditary sicknesses [7].
- Antimicrobial treatment: MNPs can be utilized to kill microorganisms and different microbes, which could be utilized to treat irresistible sicknesses [8].

Here are Some Specific Examples of Metallic Nanoparticles used in Medicine Gold Nanoparticles

Their unique properties and versatility hold immense potential for revolutionizing various medical fields. Used for drug delivery, photothermal therapy, bioimaging, and biosensing (Figure 2) [9].

- Drug delivery: AuNPs can carry drugs directly to diseased cells, reducing side effects and improving treatment efficacy.
- Photothermal therapy: AuNPs absorb light and convert it into heat, allowing for targeted destruction of diseased cells like cancer cells.
- Bioimaging: AuNPs act as contrast agents, enhancing the resolution and clarity of medical scans like MRI and CT.
- Biosensing: AuNPs can be designed to detect specific molecules like disease biomarkers, enabling rapid and highly sensitive diagnostics.

Silver nanoparticles

Silver nanoparticles (AgNPs) are another shining star in the world of nanomedicine, boasting unique properties and promising applications alongside their golden cousins. Used for antimicrobial therapy and wound healing [10].

- Antimicrobial therapy: AgNPs possess potent antimicrobial activity against bacteria, fungi, and even some viruses. They are tiny silver shields protecting cells from a wide range of invading pathogens.

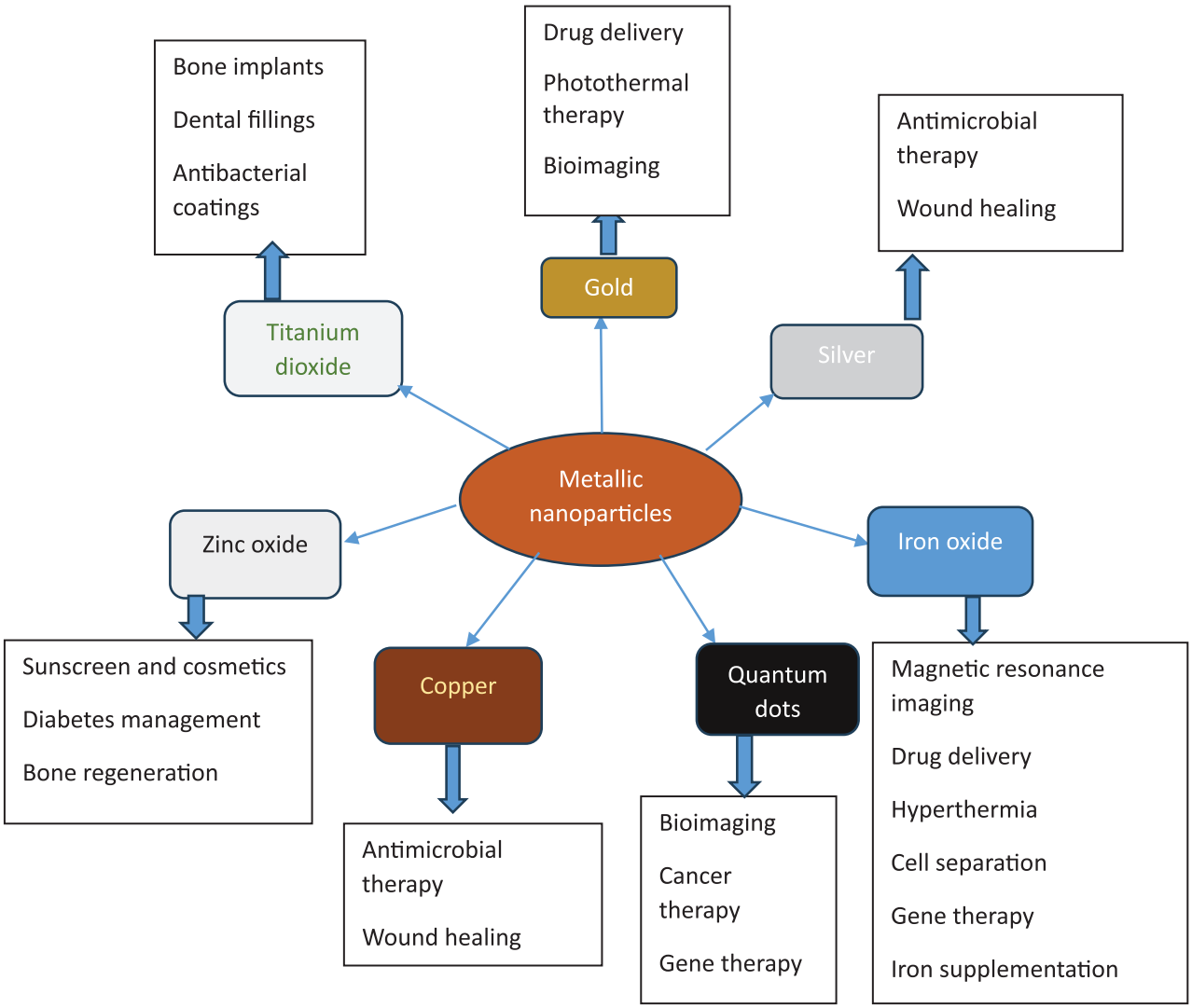

Figure 2) *Shows various metallic nanoparticles uses in medicine.*

- Wound Healing: AgNPs promote wound healing by reducing inflammation, fighting bacteria, and stimulating tissue regeneration. They are like tiny first-aid kits accelerating the healing process.

Iron oxide nanoparticles

These nanoparticles possess unique properties that make them incredibly valuable in the field of medicine. Used for MRI contrast agents, drug delivery, hyperthermia, cell separation, gene therapy and iron supplementation [11].

- Magnetic Resonance Imaging (MRI): IONPs can act as contrast agents, enhancing the visibility of specific tissues and organs in MRI scans. This allows for better diagnosis of various diseases, including cancer, stroke and heart disease.
- Drug delivery: IONPs can be utilized to convey tranquilizes straightforwardly to sick tissues, decreasing secondary effects and further developing therapy viability.
- Hyperthermia: IONPs can generate heat when exposed to an alternating magnetic field. This heat can be used to kill cancer cells in a targeted manner, a technique known as magnetic fluid hyperthermia.
- Cell separation: IONPs can be attached to specific cell types, allowing them to be easily separated from a mixture of cells using a magnetic field. This is useful for research purposes and for developing cell-based therapies.

- Gene therapy: IONPs can be used to deliver genes to specific cells, potentially treating genetic diseases. The nanoparticles can be coated with DNA or RNA, and then targeted to the desired cells using a magnetic field.
- Iron supplementation: The nanoparticles can be coated with DNA or RNA, and then targeted to the desired cells using a magnetic field. The nanoparticles can be injected or taken orally, and they slowly release iron into the bloodstream.

Quantum dots

Quantum dots (QDs) are tiny semiconductor particles. Their unique quantum properties give them the ability to emit light in a wide range of colors, making them incredibly versatile for various medical applications. Used for bioimaging, cancer therapy and gene therapy [12].

- Bioimaging: QDs can be attached to antibodies or other targeting molecules, allowing them to specifically bind to diseased cells or tissues. When illuminated, they emit bright, tunable light, making it easy for doctors to visualize these targets in high detail. This can be incredibly helpful for diagnosing diseases like cancer, Alzheimer's, and even tracking infections.
- Cancer therapy: When exposed to specific light wavelengths, QDs can generate reactive oxygen species that destroy cancer cells. This targeted approach minimizes damage to healthy tissues, making it a promising alternative to traditional cancer treatments.
- Gene therapy: QDs can be used to deliver gene therapy vectors, carrying healthy genes to replace defective ones in patients with genetic disorders. This has the potential to cure previously untreatable diseases.

Copper nanoparticles

Copper, a familiar element found in our homes and even our bodies, takes on a fascinating new role in the realm of medicine when miniaturized into nanoparticles. Used for antimicrobial therapy and wound healing [13].

- Antimicrobial therapy: Copper nanoparticles are potent germ fighters, as they have ability to disrupt bacterial membranes and DNA. This makes them ideal for tackling drug-resistant bacteria, a growing global threat.
- Wound healing: Copper nanoparticles incorporated into bandages or wound dressings can prevent infections and promote faster healing.

Zinc oxide nanoparticles

Zinc oxide nanoparticles (ZnO NPs) are emerging as a highly promising material in the field of medicine due to their unique properties and potential applications. Used for sunscreen and cosmetics, diabetes management, and bone regeneration [14].

- Sunscreen and cosmetics: ZnO nanoparticles are used in sunscreens and cosmetics due to their UV-blocking properties.
- Diabetes management: ZnO nanoparticles may have potential in regulating blood sugar levels.
- Bone regeneration: ZnO nanoparticles are being explored for their ability to promote bone growth and repair.

Titanium dioxide nanoparticles

Titanium dioxide nanoparticles (TiO NPs) also play a significant role in medicine, although its recent safety concerns have sparked debate. Used for bone implants, dental fillings and antibacterial coatings [15].

- Bone implants: TiO_2 nanoparticles can be incorporated into the surface of bone implants, promoting stronger bonding with bone tissue. This is crucial for the success of implants, as it prevents loosening and failure.
- Dental fillings: TiO_2 nanoparticles can be added to dental filling materials to make them stronger and more durable, lasting

longer and requiring fewer replacements.

- Antibacterial coatings: TiO_2 NPs have antibacterial properties and can be used to coat medical devices and implants to prevent infections. This can be especially beneficial for patients with weakened immune systems or implanted devices.

Challenges

- Scalability: Efficient and cost-effective methods for large-scale production of MNPs are needed for widespread clinical use [16].
- Toxicity: Long-term toxicity and bio distribution of MNPs need further investigation to ensure their safety for clinical applications [16].
- Regulatory hurdles: Navigating regulatory pathways for clinical translation of MNP-based technologies remains a challenge [16].

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