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Popular Article

Nanotechnology: promises and challenges for veterinary science

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Abstract

Nanotechnology is a new and recent area of science and technology. Nanotechnology deals with the study of any material's size in the range of 1-100 nm. Nobel Prize winner Richard Feynman discussed for the first time the importance of nanotechnology in 1959 at Caltech (California Institute of Technology), USA. Nanoparticles can be prepared in different sizes and shapes. Various sizes and shapes of nanoparticles display different colours and chemical properties. Nanotechnology has applications and usefulness in several areas such as healthcare, defence, diagnosis and treatment of diseases, agriculture, and active and smart packaging of food products. Nanotechnology has much potential in veterinary science for animal welfare, such as early pregnancy detection platforms, pathogens detection, and new antibacterial drug development to improve animal health.

Keywords: Nanotechnology, Nanomedicine, Veterinary, Animal Health, Disease treatment

Introduction

Nanotechnology is a multidisciplinary area that covers several subjects, such as Physics, Chemistry, Biology, Medicine, and material science. Nanotechnology is also considered one of the fascinating technologies in the 21st century [1]. In the current scenario, nanotechnology has significantly impacted several areas, such as medicine, biotechnology, and the development of new diagnostic tools and therapies for animal diseases [2, 3]. Nanotechnology can revolutionize veterinary science by enhancing the accuracy and precision of therapeutic and diagnostic tools employed for animal welfare [3]. Nanotechnology has proven to be a key technology in veterinary science based on broadly five areas: drug delivery, wound healing, imaging, biosensor development,

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and food safety (Table 1). According to the dimensions, there are four categories of nanoparticles (Table 2). Nanoparticles can be prepared from metal, metal oxide precursors, and polymers depending upon the use and application requirements. According to a particular application requirement, the size and shapes of nanoparticles can be controlled. In recent times, the use of nanomaterials-based hydrogels has increased significantly in the treatment of diseases.

Table1: Use of nanotechnology in veterinary science

Application area	**Utility**
Drug delivery	Delivery of drugs to specific cells and tissues
Wound healing	Nanofibers or polymer-based dressings for faster wound healing and prevention of infection
Imaging	Use of nanoparticles in MRI and CT scans to diagnose diseases more accurately.
Biosensor development	Detection of disease biomarkers in animals' saliva, blood, and urine samples
Food safety	Detection of contaminants and pathogens in animals' feed and food products

Table 2: Classification of nanoparticles according to dimensions.

Dimension of nanoparticles	**Description**	**Examples**
0-D	➢ All the dimensions are at the nanoscale.	Quantum dots
1-D	➢ Two dimensions are in the nanoscale, and the rest is on the macro-scale.	Nanowires, nanofibers, nanobelts, nanorods, nanotubes
2-D	➢ Only one dimension is in the nanoscale.	Nanosheets, nano-membranes, nanowalls, nano prisms
3-D	➢ All dimensions are at the macro-scale.	Composites made up of different nanostructures.

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Nanoparticles can be synthesized by various methods (Figure 1) and characterized by numerous techniques (Figure 2).

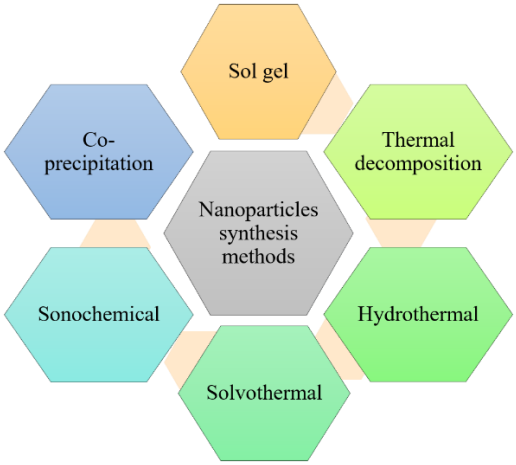

Figure 1: Synthesis methods for nanoparticles.

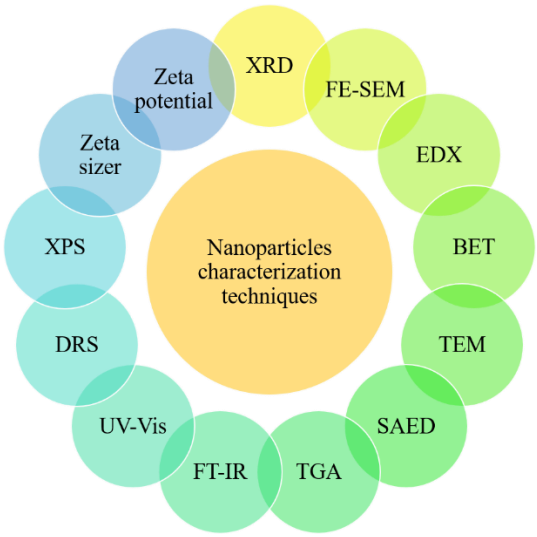

Figure 2: Characterization techniques for nanoparticles.

Nanotechnology has a crucial role and impact in veterinary science as it helps in the more precise and fast detection, treatment, and prevention of animal diseases in a much more economical way [4]. More economic diseases treatment of animals will also reduce the financial burden and stress on farmers. It is estimated that 600 million farmers in underdeveloped nations rely on domestic animals for income, significantly impacting a country's GDP because domestic animals are a source of various agricultural products. Zoonosis is a considerable hurdle in veterinary science today as there is a delay in detecting and controlling several animal diseases caused by various

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microorganisms. Delay in detecting and treating animal diseases is a huge concern from the animal safety point of view and farmers' monetary loss. In the current scenario, nanomedicine has emerged as a new therapeutic platform, especially in disease detection and treatment. Nanomedicine is gaining increased interest from the scientific community due to its stability, biocompatibility, biodegradability, and good absorption, distribution, metabolism, and excretion (ADME) features. Nanomedicine is more effective and requires less amount during treatment than conventional drugs [5].

Nanomedicine in animal disease diagnosis and treatment

Nanomedicine has tremendous potential in animal disease detection and treatment. Veterinarians face several diseases in animals, namely FMD (Foot and mouth disease), brucellosis, methicillin-resistant Staphylococcus aureus (MRSA), and even infection in the blood [6]. Various nanoparticles are useful in animal disease treatment therapies, such as silver, gold, iron oxide, zinc oxide, liposomes, dendrimers, and polymers (chitosan and PLGA). Antibiotic drugs can be encapsulated inside or on the surface of these nanoparticles and delivered to the infected sites. Nanomedicines have more specificity and sensitivity than conventional drugs. This fact has been well-established and confirmed by various researchers worldwide. *Pseudomonas aeruginosa* bacterial infection is also observed in animals [7]. This bacterial infection is not successfully cured completely using conventional antibiotics due to less membrane permeability of *P. aeruginosa*. When the antibiotics (e.g., gentamicin) are conjugated with the nanoparticles, then the antibiotics will be released at the infected site so that the required dose is available at the infection site to cure the disease. Lab-on-a-chip (LOC) is a nanodevice that can detect even a pico-liter sample volume of DNA/protein in disease samples [8]. In the USA, gold nanoparticles have been investigated in the prostate cancer surgery of dogs [6].

Nano-bio chips have been utilized to detect pathogens, understand the genetic factors responsible for disease occurrence, and test drug efficiency and gene expression studies [9, 10]. Nanomedicine dramatically aids the development of new vaccines [11]. Nano-based therapies have quickly attracted the interest of the medical and scientific community following the COVID-19 pandemic. Trials of vaccines based on nanoparticles are ongoing both in India and overseas. Successful development of nano-based vaccines will ease the detection of viral diseases. Gold nanoparticle-based vaccines have been utilized to cure FMD disease in animals. Silver nanoparticle-

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based shampoos have been used as a surface disinfectant for pets.

Challenges of nanotechnology in veterinary science

Though nanotechnology has massive utility in veterinary science, there are many challenges and issues to be addressed before the long-term use of nanomaterials for veterinary sciences for several purposes, which are as:

1. **Safety:** Nanomaterials toxicity is still a significant issue, and safety parameters for nanomaterials and their use on animals and the environment must be addressed.
2. **Regulatory issues:** There need to be clear guidelines on using nanotechnology in veterinary sciences. This can cause hindrances in the design and development of new products for animal welfare.
3. **Cost:** Nanotechnology-based animal-use products may be expensive, limiting the easy availability for animal owners.
4. **Ethical considerations:** Using nanoparticles in veterinary medicine might be a matter of moral concern without the known impact of nanoparticles on animal systems.
5. **Public acceptance:** Due to the safety issues of several nanoparticles and their impact on animals and human beings, there is always a fear among the social community to accept the use of new technology for animal welfare.

Summary

Nanotechnology is providing new opportunities and alternative solutions in medical science. Nanoparticle-based therapeutics are now gaining more interest in the public domain due to their high specificity and compatibility with living systems. Due to the availability of several types of nanoparticles, more options are open for developing novel therapeutic agents which can cure various diseases in animals with more comfort.

Prospects

Adopting a new technology may pose a health risk due to the need for more thorough research on toxicity and bio-accumulation parameters. Extensive research and surveys must be conducted to identify the effects of products based on nanotechnology on living beings and their persistence in the environment. In the United States, the Food and Drug Administration and Environmental Protection Agency are focusing on the health and safety implications of nanoparticles. Further, there is a need

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for in-depth nanomaterials-based cell interaction studies in vitro and in-vivo models to develop more safe and advanced therapeutic products and devices for the rapid treatment of animal diseases.

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