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Review on Common Nanoparticles Use in Treatment of Parasitic Infection

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ABSTRACT

Parasites are organisms that depend on a host organism for their survival and obtain nutrients from them. They can either live on or inside the host. They have the potential to induce a diverse array of illnesses, spanning from malaria and trypanosomiasis to intestinal worms. Nanoparticles have the potential to revolutionize vaccine development for parasitic infections by improving antigen delivery, adjuvant effects, and overall vaccine efficacy. They provide creative answers to tackle the distinct difficulties presented by parasitic illnesses, getting us nearer to the objective of managing and eradicating these infections. Nonetheless, it is crucial to persist with the exploration and enhancement of nanoparticle-centered parasitic vaccines to guarantee their safety and efficacy. Additionally, it is imperative to navigate the regulatory channels for the authorization and dissemination of these vaccines. One of the most common nanoparticles used in parasitic disease treatment is liposomes. Liposomal drug delivery systems have shown their potential in improving drug solubility, stability, and targeted delivery to infected tissues. This has led to improved drug efficacy while minimizing side effects. Liposomal formulations have been successfully employed in the treatment of a range of parasitic diseases, such as leishmaniasis, malaria, and trypanosomiasis.

Introduction

The term "parasite" has its origins in the Greek language. The term is comprised of two terms: 'para' which signifies 'besides' and 'sitos' which denotes 'food'. e.g., The presence of Ascaris, a parasite, in the human body Parasites are organisms that depend on a host organism for their survival and obtain nutrients from the host. According to Landfear (2011), they have the potential to induce various illnesses, including but not limited to malaria, trypanosomiasis, and intestinal worms. Traditional treatments for parasitic infections often involve drugs that may have limited effectiveness due to parasite resistance, and these drugs can have adverse side effects on the host, making long-term treatment challenging (Capela et al., 2019).

There are two types of parasites:

1. Ectoparasites are parasitic groups that infest the host's skin or external parts of the host's body, resulting in infestation. Examples of such ectoparasites include mosquitos, pediculous, and ticks.
2. Endoparasites are made up of parasitic categories that invade the internal regions of the body (e.g., Giardia lamblia, Plasmodium spp., and Leishmania spp.), resulting in infection.

Parasites also can be classified into:

1: Facultative parasite: the parasite that can live in his life cycle as a parasite or as a free living Ex. Strongyloides stracularis, Crysoma buziana.

2: Obligatory parasite: this group must be living as a parasite in all or part of its life cycle, ex. lice (Assafa et al., 2004).

The term nanotechnology was initially coined by Professor Norio Taniguchi from the University of Tokyo in 1974. He employed this term to refer to the utilization of nanoparticles in various tools. Nanotechnology is defined as the engineering, characterization, manufacture, and use of materials and tools with a scale of 100 nanometers or less (Wang et al., 2012). The word nanotechnology is also used to describe materials, devices, and systems with new and improved compositions and components, such as biological, physical, and chemical properties. Nanotechnology has become the most widely used word these days. It is expected that pharmaceutical nanotechnology will make developments in the pharmaceutical industry due to its great effectiveness in drug delivery, diagnostics, imaging, and biosensors (Shankar et al., 2013).

Properties of Nanoparticles:-

There are many properties of nanoparticles, including:

Nanocarriers are inorganic nanoparticles with excellent features, especially when used in drug delivery systems because of the possibility of loading drugs on them and reducing side effects. Many organic pharmaceutical drugs have been loaded on these compounds, and then they are called smart drugs that may revolutionize disease treatment (Nair et al., 2016) through sustained drug release to improve target cell properties, improve health, and extend survival (Nalawade et al., 2009).

Drug Delivery

To improve the delivery of the drug to the target cells with the lowest concentrations and to protect other healthy tissues and cells of the body from the influence of these chemicals, the need to use drug delivery systems (DDSS) emerged because current anti-cancer chemical treatments often show negative effects. Harmful toxicity and low efficacy due to the failure to differentiate between cancerous and normal cells by the same treatments, as well as the development of drug resistance (Jaracz et al., 2005).

Nanoparticles offer several advantages when it comes to treating parasites:

• Targeted Delivery: Nanoparticles can be engineered to target specific parasites or infected cells, minimizing damage to healthy tissues.

• Enhanced Drug Stability: Nanoparticles can protect drugs from degradation, improving their stability and increasing their half-life in the body.

• Reduced Side Effects: Precise targeting can minimize the impact of drugs on healthy cells, reducing side effects. Nanoparticles can help overcome drug resistance by delivering drugs directly to the parasite's site of action (Sun et al., 2019) .

Applications of Nanoparticles in Parasite Treatment:

Drug Delivery: Nanoparticles can encapsulate drugs, allowing for controlled release and improved bioavailability.

Imaging and Diagnosis: Nanoparticles can be used as contrast agents in medical imaging to aid in the diagnosis of parasitic infections.

Vaccine Development: Nanoparticles can serve as carriers for antigens, enhancing the effectiveness of vaccines against parasitic diseases.

Gene Silencing: RNA interference (RNAi) using nanoparticles can be employed to target and inhibit essential genes in parasites.

Challenges and Future Directions: While nanoparticles show great promise in parasite treatment, there are still challenges to overcome, such as ensuring the safety and biocompatibility of these materials. Additionally, regulatory approval and cost-effectiveness will be important considerations for widespread adoption (Volpedo et al., 2019).

Application of nanoparticles in vaccine development for parasitic infections:

Vaccine Development Using Nanoparticles:

Vaccines are one of the most effective ways to prevent parasitic infections, but they often face challenges related to the complexity of parasitic organisms and the need for potent immune responses (Sharma et al., 2015). Nanoparticles provide a versatile platform for enhancing vaccine development against parasitic diseases in several ways:

Notable examples of nanoparticle-based parasitic vaccines include efforts to combat malaria, leishmaniasis, and schistosomiasis. In the case of malaria, researchers have developed nanoparticles carrying malaria antigens that stimulate strong and long-lasting immune responses, offering hope for a more effective vaccine against this deadly disease (Pati et al., 2018).

Common nanoparticles used for parasite treatment:

Nanoparticles have demonstrated significant promise in the realm of parasite treatment as a result of their distinct characteristics and abilities. Several types of nanoparticles have been explored for their efficacy in combating parasites and controlling their spread: -

1. Silver Nanoparticles: Silver nanoparticles have broad-spectrum antimicrobial properties, including against various parasites. They exhibit excellent biocidal activity by disrupting the cellular structures and metabolic processes of parasites. Silver nanoparticles have been studied for their effectiveness against parasites such as Leishmania, Plasmodium, and Trypanosoma (Rai et al., 2014).

2. Gold Nanoparticles: Gold nanoparticles exhibit remarkable physical and chemical

characteristics, rendering them appropriate for diverse biomedical uses, such as the treatment of parasites. Functionalized gold nanoparticles can target specific parasites and inhibit their growth. They have been explored for the treatment of parasites like Giardia lamblia and Plasmodium falciparum (Benelli, 2018).

3. Magnetic Nanoparticles: Magnetic nanoparticles, often made of iron oxide, have the potential to be utilized for precise drug delivery and the treatment of parasites. The therapeutic efficacy of these nanoparticles can be enhanced by utilizing external magnetic fields to guide them to specific locations within the body. According to Kannan et al. (2019), there has been research conducted on the use of magnetic nanoparticles for the treatment of parasitic infections like malaria, schistosomiasis, and filariasis.

4. Lipid-based nanoparticles, including liposomes and solid lipid nanoparticles, represent two distinct categories of biocompatible carriers capable of encapsulating and transporting antiparasitic medications. These nanoparticles protect the drug payload from degradation and enhance its stability and bioavailability. Lipid-based nanoparticles have been utilized for the treatment of parasites like Leishmania, Toxoplasma, and Plasmodium (Puri et al., 2010).

5. Carbon-based nanoparticles, such as carbon nanotubes and graphene oxide, have been extensively investigated due to their potential as antiparasitic agents. These nanoparticles can directly interact with parasites like leishmania and reduce the replication of parasites with no side effects compared with Amphotericin B drugs (Gedda et al., 2020).

Conclusion:-

Nanoparticles have emerged as a promising tool in the treatment of parasitic diseases, addressing some of the challenges associated with conventional therapies. Among the various nanoparticles used in this context, several have proven to be particularly effective and widely adopted.

Nanoparticles like polymeric nanoparticles and dendrimers have also played significant roles in parasitic disease treatment. Their versatility in encapsulating and delivering a wide array of anti-parasitic drugs has led to better therapeutic outcomes. Additionally, it is possible to alter these nanoparticles in order to achieve controlled drug release, thereby guaranteeing extended drug presence at the site of infection.

Nevertheless, it should be emphasized that the utilization of nanoparticles in the treatment of parasitic diseases is a developing area, requiring further investigation to comprehensively comprehend their enduring safety and enhance their efficacy. Moreover, the specific choice of nanoparticles may vary depending on the type of parasitic disease, the target tissue, and the drug being delivered.

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