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Nanotechnology based Methodologies for HIV/AIDS Prevention and Treatment

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ABSTRACTION :

As antiretroviral therapy (ART) advances, the human immunodeficiency virus (HIV) remains a global health concern. However, creative solutions are required due to the drawbacks of conventional therapy, such as poor patient adherence, toxicity, and medication resistance. By utilizing nanoscale materials and devices, nanotechnology presents intriguing ways to improve HIV/AIDS prevention, diagnosis, and therapy. Recent developments in nanotechnology-based approaches, such as drug delivery systems, diagnostic instruments, vaccine development, and preventative measures, are examined in this study.

Introduction

HIV/AIDS continues to be one of the world's most urgent public health concerns, affecting millions of people each year. Although the quality of life for individuals with HIV has greatly improved thanks to conventional ART, problems such systemic adverse effects and insufficient viral suppression still exist. The manipulation of matter at the molecular or atomic level, or nanotechnology, offers chances to overcome these obstacles through creative medical applications**.**

Nanotechnology to Deliver HIV/AIDS Drugs

Drug delivery systems (DDS) based on nanotechnology have demonstrated a great deal of promise in enhancing the pharmacokinetics and pharmacodynamics of antiretroviral medications. Important tactics consist of:

Polymeric Nanoparticles

Polylactic-co-glycolic acid (PLGA), a biodegradable polymer, is used to encapsulate antiretroviral medications.
Benefits: Better patient compliance, fewer doses, and prolonged medication release.

The nanocrystals

To improve solubility and absorption, pure medication particles are lowered to the nanoscale.
Use: Nanocrystals of efavirenz have enhanced oral absorption.

Nanocarriers with hybrid properties
targeted and controlled release by combining the characteristics of polymers and lipids.

Nanotechnology to Diagnose HIV/AIDS

Effective care of HIV depends on an early and precise diagnosis. Diagnostic instruments based on nanotechnology provide quick findings, excellent sensitivity, and specificity. Among the notable innovations are:

Nanobiosensors

using nanoparticles—like gold or quantum dots—integrated into biosensors to accurately identify HIV-specific biomarkers.
For instance, HIV-1 RNA can be detected by electrochemical sensors that use gold nanoparticles.

Devices at the Point of Care

Nanomaterial-based portable diagnostic tools that provide fast results in environments with limited resources.
As an illustration, consider lateral flow tests using paper and silver nanoparticles.

Systems of Microfluids

Multiplexed HIV and co-infection detection is made possible by lab-on-a-chip systems.

Nanotechnology to Develop HIV Vaccines

In the field of global health, creating an effective HIV vaccine is still a top goal. One way that nanotechnology helps is by:

Systems for Antigen Delivery. HIV antigens are presented and delivered to the immune system more effectively by nanoparticles.

For instance, gp120 antigen-loaded lipid nanoparticles

Supplements

As immune-stimulatory agents, nanoparticles increase the effectiveness of vaccines.
For instance, subunit vaccinations containing aluminum hydroxide nanoparticles.

mRNA Platforms for Vaccination
HIV antigen-coding mRNA is delivered and protected by nanolipid carriers.

Preventive Techniques Employing Nanotechnology
Through creative prophylactic agent delivery systems, nanotechnology has extended preventative strategies beyond vaccinations.

Microbicides for the Vagina and Rectal Area
HIV cannot be spread through sexual contact thanks to nanocarriers that transport antiviral medications straight to mucosal tissues.
For instance, nanogels filled with dapivirine.

PrEP, or pre-exposure prophylaxis
Long-acting injectable nanoformulations that increase effectiveness and adherence.
Cabotegravir nanoparticles, for instance, allow for bi-monthly dosage.

Barrier Techniques
Condoms with antiviral coatings strengthened by nanotechnology for dual protection.

Difficulties and Potential Paths

Notwithstanding the potential of nanotechnology, a number of obstacles still exist:

Hazard and Danger

A careful assessment of the possible long-term impacts of nanoparticles on the environment and human health is necessary.

Cost and Scalability

Broad adoption in low-income environments may be hampered by high production costs and intricate manufacturing procedures.

Obstacles Regulatory

defining precise rules for nanomedicine's clinical approval.
Future studies ought to concentrate on personalized medicine strategies, multifunctional nanocarriers, and combining nanotechnology with other cutting-edge disciplines like artificial intelligence and CRISPR-based gene editing.

Conclusion

By overcoming present shortcomings in ART, diagnostics, and prophylaxis, nanotechnology holds revolutionary promise for HIV/AIDS therapy and prevention. These innovations can help achieve the worldwide aim of eliminating the HIV/AIDS epidemic by promoting multidisciplinary collaboration.

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