**CURRENT TRENDS IN NANOTHERANOSTICS**

**ABSTRACT:**
Nanotheranostics combine diagnostic and therapeutic capabilities in one system that harnesses the benefits of nanotechnology, making them attractive for personalized medicine. The term comes from Thera(py) + Diag(nostics) and combines the two disciplines for advanced applications. Theranostics nanomedicine means colloidal nanoparticles ranging in size from 1 to 1000nm (1μm). They are composed of macromolecular materials/polymers/carbon nanomaterials/metallic and inorganic nanoparticles that simultaneously adsorb, bind, trap, and encapsulate diagnostic and therapeutic agents at cellular and molecular levels for diagnosis and treatment. has been changed. In general, the unique properties of nanoparticles are used to achieve biomarker identification and drug delivery. Nanotheranostics can be applied to discover and target imaging biomarkers non-invasively and to advance therapy based on biomarker distribution. This is a large and hopeful role theranostics must fill. In this review, we have outlined how nano materials are designed and customized for nanotheranostics of cancer and other diseases such as neurodegenerative, autoimmune (particularly on rheumatoid arthritis), and cardiovascular diseases.

**KEYWORDS:**
Nanotheranostics, nanomaterials, cancer, neurodegenerative diseases, autoimmune diseases

**INTRODUCTION:**
Nanotherapeutics is to apply and further develop the various nanomedicine strategies such as polymer conjugations, dendrimers, micelles, liposomes, metal and inorganic nanoparticles, carbon nanotubes, nanoparticles of biodegradable polymers for sustained, controlled and targeted co-delivery of diagnostic and therapeutic agents for better theranostics effects and fewer side effects. The purpose is to diagnose and treat the diseases at their earliest stage, when the diseases are most likely curable or atleast treatable. Personalized, or occasionally termed precision medicine (PM), is a new trend in medicine predominantly in cancer treatment that has promise in improving healthcare before, during and after disease. This stems from the realization that no single treatment has the same effect on many patients with the same diagnosis. Instead of the most common prescriptions, PMs individualize the best treatment for each individual(1).

Nanoparticles have unique properties that provide unique imaging and functionalization utilities. Due to their size, nanoparticles are advantageous for localization to disease sites, especially cancers, in vivo. For example, nanoparticles spend more time circulating in the blood in vivo than conventional chemotherapeutic agents, depending on their surface functionalization.
Longer circulation half-lives increase the likelihood that nanoparticles will leak out of tumor blood vessels and through underdeveloped tumor vasculature into tumor tissue (2). In addition, nanoparticles have a high surface area-to-volume ratio, which provides high loading capacity for imaging probes, targeting ligands, and therapeutic molecules. Additionally, many nanoparticles have unique imaging properties that can be further functionalized to become nanotheranostics. Such a multifunctional system would be of great benefit for PMs to screen and diagnose specific molecular makeup, optimize therapeutic strategies and delivery, and monitor therapeutic efficacy in highly variable diseases such as cancer.In short, nanotheranostics can significantly improve the quality of personalized medicine (3).

NANOTHERANOSTICS AND THEIR ROLE IN THE DIAGNOSIS, TREATMENT AND PREVENTION OF COVID-19

They are currently used in the diagnosis and treatment of a variety of diseases with poor prognosis The use of nanotheranostics has gained increasing attention over the past decade, especially as new diagnostic tools for cancer (1). Treatments for fatal diseases such as cancer, neurodegenerative diseases, cardiovascular diseases, genetic diseases, and hemoglobinopathies are limited to specific patients and are selectively given according to the specific stage of the disease (2-3). The nanomaterials used include a new generation of different types of nanocarriers such as polymer conjugates, metallic and non-metallic NPs, inorganic NPs, dendrimers, micelles, and liposomes(2,6–11).

The nanotheranostics approach is superior because it monitors the delivered therapeutics and simultaneously controls the response to the treatment in real time. This reduces the possibility of over- and under-dosing. Multifunctional nanotheranostics include tumors and lesions obtained by radiolabeling nanomaterials such as gold, silver, silicon NPs, carbon nanotubes (CNTs) with nanosize, delivery, sustained release, and desaturation control includes non-invasive imaging of System (1-4,12).

Nanotheranostics media enable long-term circulation of nanomaterials in the blood, efficient release behavior, tissue targeting, good penetration, excellent sensing capabilities, and high target-to-background ratios and low undesirable side effects. must have good imaging. The
virus entry pathway is initiated by the binding of the viral S protein to her ACE2 receptor. After the binding event, cell entry occurs via protease-activated transmembrane serine protease 2 (TMPRSS2).

Internalization is followed by virus entry into endosomes, where virus particles release genetic material for protein synthesis, leading to synthesis of new infectious particles and host infection. Nanotechnology offers a promising means of combating her ongoing COVID-19 outbreak and future pandemics. Both conventional and advanced biomimetic approaches, including engineered biochemically functionalized NPs, are included in the area of ​​nanotechnology that can be used against COVID-19 (5-8).

Nanotechnology develops safe, efficient and targeted drug delivery, culminating in virus-host cell interaction, resulting in a risk-free and highly efficient immunity that permanently destroys virus particles. We aim to produce a nanovaccine that will generate Better drug delivery via
nanocarriages (9,10).

DELIVERY OF REPURPOSED DRUGS VIA NANOCARRIERS

 For SARS-CoV-2, the main focus now is to repurpose existing molecules for the development of specific/broad-spectrum antiviral agents. For this purpose, nanocarrier delivery systems could be very useful. Minimal water solubility, denaturation, rapid clearance, and low bioavailability seriously hinder the delivery of drugs, including peptides/proteins, DNA/RNA, etc., to target sites. The diverse properties of nanomaterials, such as high surface-to-volume ratios, biofunctionalization, unique physicochemical properties, and multiple delivery routes, are highly advantageous for overcoming challenges associated with trivial therapeutics. Biocompatible organic/inorganic nanoparticles prove to be promising candidates for providing efficient therapeutics with beneficial properties such as controlled release, improved pharmacokinetics and minimized drug resistance. Additionally, small in size and site specific nanovehicles have the potential to cross the biological barriers thereby accessing the pathogen-infected protected sites of the body with higher specificity and simultaneously preventing the unwanted release of drugs at non-targeted regions, hence resulting in a reduction in the amount of dose needed and systemic toxicity. Nanotechnology further makes it possible to design personalized therapy (6,13-15).

Various research groups have shown the potential nanobased therapeutics, or modulation of immune systems against various viral infections like SARS-CoV-2, herpes simplex virus (HSV-1 and HSV-2) (treated by embedding acyclovir in chitosan NPs), Venezuelan equine encephalitis virus (VEEV) (treated by utilizing lipid coated mesoporous silica nanocarrier system to carry antiviral drug ML336), and bleomycin-induced pulmonary fibrosis (treated by introducing liposomes carrying cholesterol modified hydroxychloroquine). This successful bio-prevention of viruses achieved through nano platforms could guarantee promising nano-candidates to combat various viral infections including SARS-CoV-2.

Nanomedicines have the potential to overcome antiviral drug site-specific delivery
If scientists develop effective drugs against the SARS-CoV-2 virus in the case of COVID-19 disease, an optimized targeted drug delivery system based on nanomedicine will help overcome the challenges of site-specific delivery. Nanomedicine is also useful for the controlled release and maintenance of antiviral drugs at specific sites. It plays an important role in treating viral infections (25).

**Combinatorial Therapies**:Loading Drug Cocktails onto Single Nanosystems Combinatorial therapies facilitate synergistic cross-talk suppression mechanisms that are currently being investigated to be used effectively against SARS-CoV-2. increase. Its advantages include minimal drug burden and negligible side effects [26]. It also fights drug resistance at a very high level.

In this approach, multiple drugs with different physicochemical properties are loaded onto the same nanocarrier.Both hydrophobic and hydrophilic drugs can be transported within the same nanovehicle,also ensuring their continuous release.

Scientists recently developed combinatorial nanoparticles containing the endogenous lipid squalene, an adenosine immunomodulator, and α-tocopherol to develop a nanotherapy against acute viral inflammation (14).

Additionally, lipid-based nanocarriers containing lopinavir, ritonavir, and tenofovir have been prepared to treat lymphatic drug insufficiency (16–20). This system has been shown to retain 50 times higher concentrations of drug in the lymph nodes than current drug-free oral therapy. This system could also be used against SARS-CoV-2. Frequent mutations in the SARS-CoV-2 genome continuously alter antigenic proteins.

A67V, H69del-V70del, T95I, G142DV143del-Y144del-Y145del, N211del-L212I, ins214EPE, G339D, S371L, S373P, S375F, K417N, N440K, G446S,S477N, T478K, E484A, Q493R, G496S, Q498R, N501Y, Y505H , T547K, D614G, H655Y, N679K, P681H, N764K, D796Y, N856K, Q954H, N969K, and L981F are 32 mutations in the omicron spike. In addition, pseudotyped viruses expressing the S protein from other variants of current concern (VOC; alpha, beta, gamma, and delta) and variants of interest (VOI, lambda, and mu) were tested and reported. (21–27). Implementation of sensitive and specific diagnostic tools is therefore an urgent need to detect viral infection and control viral spread (28), with the goal of It's about developing efficient NP,
These nano-based strategies also expose antigenic proteins to antigen-presenting cells, resulting in enhanced delivery and therapy [2, 14, 29].

The nanomaterial gold NP-administered colorimetric assay for diagnosing viral infections is efficiently used in a very short period of time for timely and specific visual diagnosis of COVID-19 positive patients. Capping of the SARS-CoV-2 N protein with AuNPs shows selective aggregation of its antisense RNA strand, showing changes in surface plasmon resonance (SPR). Application of RNaseH further cleaved the RNA and formed a precipitate.

The antibody Binding Graph Sheet has the potential for rapid detection of target viral proteins. It can also be used for the development of COVID-19 biosensors. Theranostic NPs have also been proposed to diagnose and neutralize viruses, thereby inhibiting their survival and spread within the host.
Potential nano-based therapeutics against the COVID-19 outbreak include proteolipid nanovehicle-based fusogenic DNA vaccines, lipid NP-encapsulated mRNA vaccines (mRNA-1273), and recombinant protein NP vaccines (NVX-1273, CoV2373) and the development of paper-based colorimetric RNA sensors. The sensor used a positively charged pyrrolidinyl peptide nucleic acid probe (acpcPNA) that aggregates negatively charged AgNPs. The acpcPNA probe hybridized to viral RNA in the presence of MERS-CoV RNA and formed a negatively charged RNAacpcPNA duplex. The duplex dispersed her AgNPs, resulting in a detectable color change due to electrostatic repulsion [30–31].

Researchers are investigating new mRNA vaccines that directly target the omicron receptor binding domain (RBD). The 'failure' of the ARCoV vaccine to neutralize sera against his Omicron variant, he strongly emphasizes the development of mRNAs encoding her RBD and lipid NP formulations of Omicron as potential candidates. Of the 18 proposed mRNA constructs with different untranslated regions (UTRs), two of them, namely Omicron/1 and Omicron/2, were selected and found to be the most suitable for intravenous injection.

Both LNP-formulated mRNA and ARCoV Omicron are effective in generating Omicron RBD in mouse serum. A final clinical-grade mRNA vaccine is currently in production [32-34].
Cancer, Covid-19, and similar pandemics can also be successfully addressed using nanotherapeutics in the same way. 3D nanotechnology-based approaches have high potential for proof-of-concept, prognosis, and mediation. The principles of tissue and cell targeting that apply to cancer and neurodegenerative diseases by administering nanoparticles can also be effective against antiviral infections and cure infected patients. These theranostic NPs can also kill viruses simultaneously. Nanoparticles can be used to create ultrafine filters for face masks, personal protective equipment (PPE), and surface coatings. These nanotheranostic approaches can help combat COVID-19 and similar pandemics in a very timely and effective manner [14].

**Conclusion**
Nano-based therapeutics have the potential to diagnose, treat and even prevent many deadly diseases such as neurodegenerative diseases, cancer and HIV-AIDS. Today, the COVID-19 outbreak has thrown the world into chaos, forcing everyone to stay at home. These antiviral pandemic outbreaks can also be included in tracking systems through the integrated approach of nanotheranostics to cure infections and prevent future devastating outbreaks. Various metallic NPs such as AuNPs and AgNPs are covered in this chapter. Moreover, the superparamagnetic and hyperthermic properties of MNPs make them highly potential tools for treating microbial infections. Nanovaccines with the ability to treat various microbial infections are being discussed.Chapters in this book also briefly describe nano-based therapeutics for the ongoing fight against the viral pandemic COVID-19. For example, a lipid NP has been developed that encapsulates an mRNA vaccine (mRNA-1273), thus serving as a potential DNA vaccine for COVID-19. Other mRNA constructs that may generate the Omicron RBD in mice, such as Omicron/1 and Omicron/2, are in late-stage clinical trials. These advances in nanotechnology have great potential for treatment and prevention of microbial outbreaks leading to epidemics or pandemics.

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