



A COMPREHENSIVE REVIEW ON NANOMEDICINE BASED NANOPARTICLES FOR CANCER THERAPY

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ABSTRACT

This review provides characteristics, and uses of nanoparticles (NPs), which come in a variety of forms. Nanoparticles (NPs) are materials with a size range of 1 to 100 nm. Based on their characteristics, forms, or sizes, they can be divided into several classes. Fullerenes, metal NPs, ceramic NPs, and polymeric NPs are among the various groups. NPs' large surface area and nanoscale give them distinct physical and chemical characteristics. Cancer is one of the significant public health problems globally and is the second leading cause of death. According to the American Cancer Society, the number of new cases is anticipated to be 2.0 million by the end of the year 2023. Nevertheless, obstacles like cytotoxicity, lack of selectivity, and multidrug resistance provide a significant obstacle to effective cancer treatment. The field of cancer diagnosis and treatment has undergone a radical change with the development of nanotechnology. Because of their unique benefits, which include improved permeability and retention impact, less toxicity, more good stability, and accurate targeting, nanoparticles (sizes ranging from 1 to 100 nm) can be utilised to treat cancer. The unique nanoparticle drug delivery technique makes use of the properties of the tumour and its surroundings. Nanoparticles overcome multidrug resistance in addition to the drawbacks of traditional cancer treatment. New avenues for the therapy of cancer have been opened up by the therapeutic implications of nanoformulations. Nevertheless, the majority of research is restricted to in vivo and in vitro investigations, and the quantity of authorised nanodrugs has not increased significantly over time.

KEYWORDS: Nanoparticles, Cancer, chemotherapy, carbon nanotubes, drug delivery.

INTRODUCTION

The prefix "nano" has found in last decade an ever-increasing application to different fields of the knowledge. Pharmaceutical nanoparticles are defined as solid, submicron-sized (less than 100 nm in diameter) drug carrier that may or may not be biodegradable. Nanoparticles (NPs) usually refer to particles 1 to 100 nm in size and the catalytic and adsorptive properties are very good for nanoparticles of certain materials. Nanomaterials are also known as "zero-dimensional" NPs. This definition is based on the fact that all of their dimensions are in the nanoscale, as opposed to one-dimensional nanomaterials (NMs) (such as nanowires and nanotubes), which have one dimension larger than the nanoscale, and two-dimensional NMs, which have two dimensions larger than the nanoscale (such as self-assembled monolayer films). They are categorized into numerous classes based on their properties, shapes, and sizes. Fullerenes, metal NPs, ceramic NPs, and polymeric NPs are among the different groups. Because of their large surface area and nanoscale size, NPs have

distinct chemical and physical properties. Their optical properties are said to be size-dependent, imparting distinct colors due to absorption in the visible area. Many features that are unique to nanoparticles are directly related to particle size.

The word Nano was derived from Latin word, which implies dwarf. Variation of size technology in Nano dosage forms to 1000 millionths of a selected unit. Nanotechnology belongs to the category of science which gives information about the processes that happen at cellular level. Engineering science was that includes between 10⁻⁹ and 10⁻⁷ of a meter.^[1] This forms associate degree freelance branch of nanostructures, referred as Nano drugs that are specifically used for medicines. The main goal of Nano dosage forms was to treat the various types of cancers with a targeted tissue delivery without producing any adverse effects. The advantages of Nano dosage forms are reduces the drug resistance, Lowers the toxicity, Enhance oral bioavailability, Increases the rate of dissolution, Increased solubility Enhances the

stability formulations and Drugs, Increases a drug targeting ability, Increase patient compliance, Enhances surface area. Nanotechnology was economical in rising absorption of the medicine, protects therapeutically active agents from physiological targets, alters the event of newer categories of biologically active macromolecules.^[2-3]

CLASSIFICATION OF NANO SIZED PARTICLES

Nanoparticles are basically classified in to three classes^[4]

A. 1-dimensional Nanoparticles

These have been used from past 10 years. Unattractively thin films (size range one–hundred nanometer) or one

layer was presently using in the field provides different applications, in sensitizing chemical and biological agents.

B. 2-dimensional Nanoparticles

Carbon nanotubes

C. 3-dimensional Nanoparticles

Dendrimers, Quantum Dots, Fullerenes

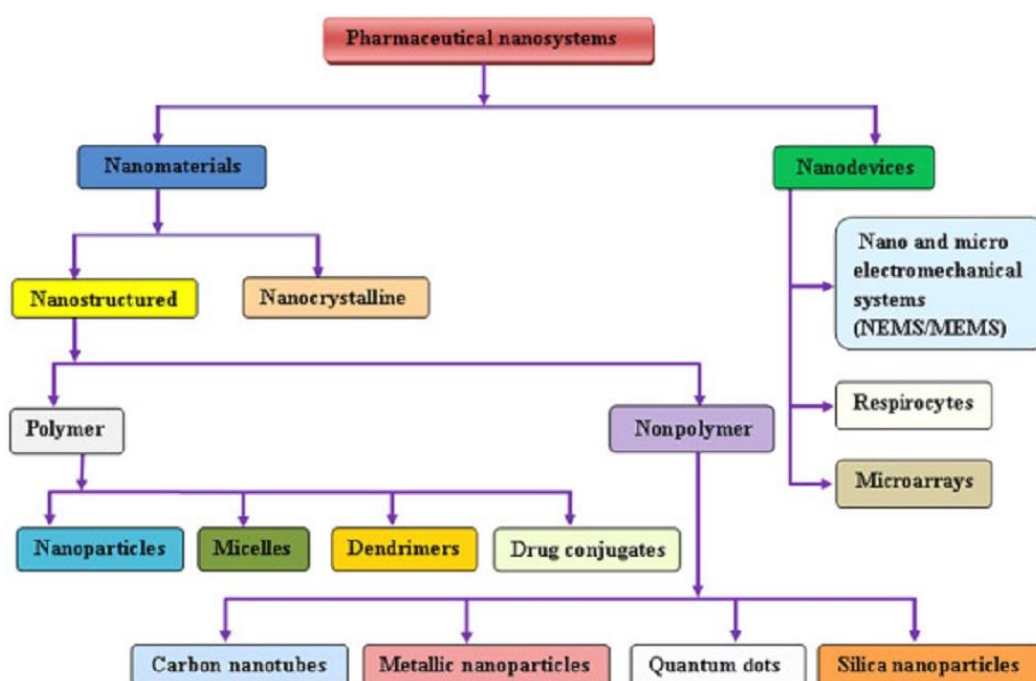


Figure 1: Diagrammatical representation of various types of pharmaceutical nanosystems.

PREPARATION OF NANOPARTICLES

Nanoparticles preparation depends on the physical and chemical nature of the polymers used and incorporation of the drug and is by prepared by using different materials which includes synthetic polymers liproteins and polysaccharides. Thematrix materials selection depends on various factors. Nanoparticles can be produced by different ways.

Evaporation of the solvent

This technique is widely used for the production of nanoparticles. (first is emulsification of the compound answer into associate degree binary compound part and second is evaporation of polymer solvent, causing compound precipitation as Nanospheres). Mixture obtained was emulsified erectile dysfunction in an solution.

The watery solution is filled with wetting agent or to form oil in water (o/w) emulsion.^[5] Ultrasonication or high-speed blend was typically utilized so as to

supply little particle size.^[6-10] Polymers utilized by the technique are PLGA^[11-12], cellulose esterphthalate^[13], Ethyl Cellulose^[14], Poly (β -hydroxybutyrate)^[15], PCL.^[16]

Emulsification and diffusion of solvent technique

This technique was most efficiently used for the preparation of nanoparticles. The polymer is encapsulated and dissolved in water miscible solvent and then saturated with water for the thermodynamic equilibrium of both the liquids. Water polymer saturation solvent was then emulsified in water with a suitable stabilizer which causes solvent diffusion and formation of nanospheres and finally solvent was evaporated.^[17]

Evaporation and double emulsion method

This method has the poor entrapment for the hydrophilic drugs and to overcome this problem emulsification was done twice, which involves to te organic polymer solution. Aqueous solution was added for the formation of water in oil phase and formed phase is added to the another aqueous phase for the formation of w/o/w

emulsion The formed emulsion was subjected to evaporation for the removal of solvent and the formed nanoparticles are separated by the process of high centrifugation.^[18-19]

Technique of Salting out effect

This technique was based on the principle that separating a water miscible solvent from water phase by salting out effect. Primarily drug candidate and polymer was solubilised in solvent & then subjected to emulsification into water gel which should contain an electrolyte along with one stabilizer. The formed o/w emulsion was added with water for the enhancement of diffusion of solvent into water phase which leads to formation of nanoparticles.^[20]

Advantages: They do not need an raise of temperature and useful when heat sensitive substances have to be processed.^[21]

Disadvantages: Application was limited to lipophilic drug and the extensive nanoparticles washing step.

CHARACTERIZATION TECHNIQUES OF NANOPARTICLES

Nanoparticles Characterization was determined by charge present on the surface, their size and morphological features. The modern techniques like AFM, SEM and TEM are widely used methods. Morphology of surface size and shape was determined by electron microscopic methods.

Dynamic Light scattering technique (DLS)

The most popular and fast methods like dynamic light scattering (DLS) or photon-correlation spectroscopy (PCS), Dynamic light weight scattering (DLS) technique for correct methodology for estimation of the particle size and size distribution.^[22]

Electron Scanning Microscopy (SEM)

Electronic microscopic technique determines the surface morphology proper visualization of nanoparticles and has various advantages in analysis of size and morphology and provides less information about distribution of size and true average population. During SEM characterization process, nanoparticles containing solution was converted into dry powder and it is mounted on sample holder followed by coating was done with a conductive metal.^[23]

Surface Charge

Intensity and charge of surface nanoparticles determines environmental and biological interaction. Zeta p potential is an indirect live of the surface charge and obtained by evaluating the potential between the outer physiologist plane and surface of shear. Thus letter potential of mixture dispersion assists indirect analysis of its storage stability to realize stability and to avoid aggregation letter potential (high letter potential values, either positive or negative) values were measured and

these values will be utilised in evaluating the character of fabric encapsulated among the Nano-capsules or coated onto the surface.^[24]

APPLICATIONS OF NANOPARTICLES

The numerous applications of NPs and nanomaterials (NMs) in materials ranging from adsorbent and water treatment to biomedical applications include polymers, food packaging, flame retardants, batteries and super capacitors, nanoceramics, light control, and medicine. These nanoparticles are being studied for a variety of applications, including potent antimicrobial agents, electrochemical sensors and biosensors, medicine and healthcare, agriculture, crop biotechnology, pests, nutrients, and plant hormones, as well as their in vitro anticancer efficiency.

A) Applications of Nanoparticles in Medicine

Silver Nanoparticles

First, it has unusual bactericidal and antiviral activity. Humans have long known the antimicrobial properties inherent in silver ions. It is widely used in medical and everyday textiles and health care products; Nano Silver powder can replace precious metal powder to make an electronic paste with better performance.^[25-27] This technology can promote further optimization of microelectronics processes. Experiments have shown that the density of NPs kills all known microorganisms (including the AIDS virus) without destroying them. Furthermore, unlike antibiotics, which have compromised activity against harmful viruses and infected cells, the action of the NPs is highly selective: they act only on the viruses and do not damage the cell!^[28]

Nano Zinc Oxide

ZnO NPs have many unique properties (including bactericidal properties, cytocompatibility, and high safety profile toward human skin)^[29], which have the potential to absorb a wide range of electromagnetic radiation, including ultraviolet, infrared, microwave, and radio frequencies.^[30] High-purity ZnO NPs are designed for use in electronics, catalysts, medical products, and personal care products.^[31]

Nano Silica

Silicon dioxide (SiO₂) NPs have a fantastic property: if applied to any material, they attach to its molecules, allowing surfaces to expel dirt and water.^[32-34] Dendritic fibrous nano-silica (DFNS) has also been reported to have biological applications such as cell therapy, gene therapy, immunological therapy, drug delivery, imaging, photothermal therapy, bioanalysis, biocatalysis, and tissue engineering.^[35]

B) Nanotechnology in Pharmaceuticals and Medicine

The targeted design industry for new drugs or drug design is directly related to NT because reactive substances such as drugs and targets represent molecular

substances.^[36] The basic concepts used in drug design are target and drug. Target is a macromolecular biological structure that is associated with a specific function, the violation of which leads to disease and requires a particular influence. The most common targets are receptors and enzymes. Super molecular structures are undoubtedly a suitable object for further study of nanocrystals. A system of proteins up to UM) that provides a ligand–biojet complex (subscript–receptor or host–guest type), a super molecular structure (super molecular component) of all known components (system).^[37] The development of targeted drugs falls under the definition of NT given above, as their mode of action is based on the targeted interaction with the disease-causing bio target.^[38]

Development of Nanomedicine (NM)

The potential for using NT in medicine is ultimately the need to change the cell structure at the molecular level using nanorobots or other NT.^[39] In recent years, NM has been developing extraordinarily and has attracted public attention for its natural benefits and social contribution. The term (which also reflects perspective) means NT in diagnosing, monitoring, and treating diseases. The development of NM has been associated with revolutionary advances in genomics and proteomics, which have allowed scientists to come closer to understanding the molecular basis of diseases. NM is developing at the nanometric level by creating materials with new properties that combine genetics and proteomics data with capabilities. There are five main areas for applying NT in medicine: supply of active drugs, new methods, and therapies at the nanometer level, in vivo diagnostics, in vitro diagnostics, and medical implants. Figure 6 shows the dimensions of NM.

Nanobiotechnology and Drug Discovery for Personalized Medicine

Personalized medicine refers to specialized treatments and medications most suited to an individual.^[40] Current efforts utilizing pharmacogenomics and pharmacogenetics include matching existing treatments to the proper people for optimal efficacy and safety. In addition to aiding the integration of diagnostics and therapies, NB promises to facilitate the identification of tailored medicines.

Nanoparticles in Drug Delivery

Depending on the physicochemical features of the medication, it can be physically trapped within the hydrophobic cores of micelles, similarly confined in the aqueous space, or intercalated into the lipid bilayer of liposomes. The drug of interest is dissolved, entrapped, attached, or encapsulated throughout or within a polymeric matrix in nanospheres. Antigen-loaded nanospheres have the potential to be used in vaccine delivery. NPs can be used to deliver drugs across the BBB. Anti-cancer medications, DNA, and vaccinations can be given via natural polymers such as chitosan. As gene carriers, chitosan–DNA NPs can be employed.

Because of their bioavailability in deep lung tissue and ease of distribution, NP aerosols are appealing for drug delivery. SWCNTs can carry drugs, antigens, and genes, and functionalized SWCNTs with DNA attached can boost uptake and expression more than free DNA.^[41]

Nanoparticles in Medical Imaging

Traditional biological imaging of cells and tissues employing fluorescence microscopy and current magnetic resonance imaging (MRI) of various body locations can benefit significantly from NPs. NPs utilized in these two processes differ in chemical composition. Magnetic resonance, tissue repair, detoxification of biological fluids, drug delivery, imaging contrast enhancement, and hypothermia treatment are all in vivo applications for super paramagnetic iron oxide NPs. Semiconducting QDs have several advantages over organic fluorophores for following cells in vivo at high resolutions.

ROLE OF NANOPARTICLES IN CANCER DRUG DELIVERY

NPs have significantly impacted cancer treatment, as indicated by the clinical trials of several NP-based medicines and delivery methods.^[42-43] Recent reviews have provided examples of various liposome and polymer-based drugs and therapeutic agents. Paclitaxel is a well-known anti-cancer drug used to treat ovarian, cutaneous, esophageal, and lung cancers. This medication inhibits cancer cell activity by stabilizing microtubules, eventually leading to apoptosis. This water-insoluble medicine is most commonly administered as an ethanol solution combined with a polyoxyethylated castor oil (Cremophor EL) solvent. The side effects of Cremophor, including hypersensitivity reactions, necessitated the use of steroids and antihistamines as pre-medications, which was a fundamental flaw in this method. Abraxane, a distinct type of paclitaxel, was licensed for clinical usage in early 2005. In a high-pressure emulsification method, paclitaxel is loaded into albumin NPs, a natural polymer. This soluble version of paclitaxel has been found to eliminate the harmful effects of Cremophor but also to provide some additional advantages. Compared to Taxol, the albumin carrier improves drug delivery from the bloodstream to the tumor site and allows for larger drug doses.

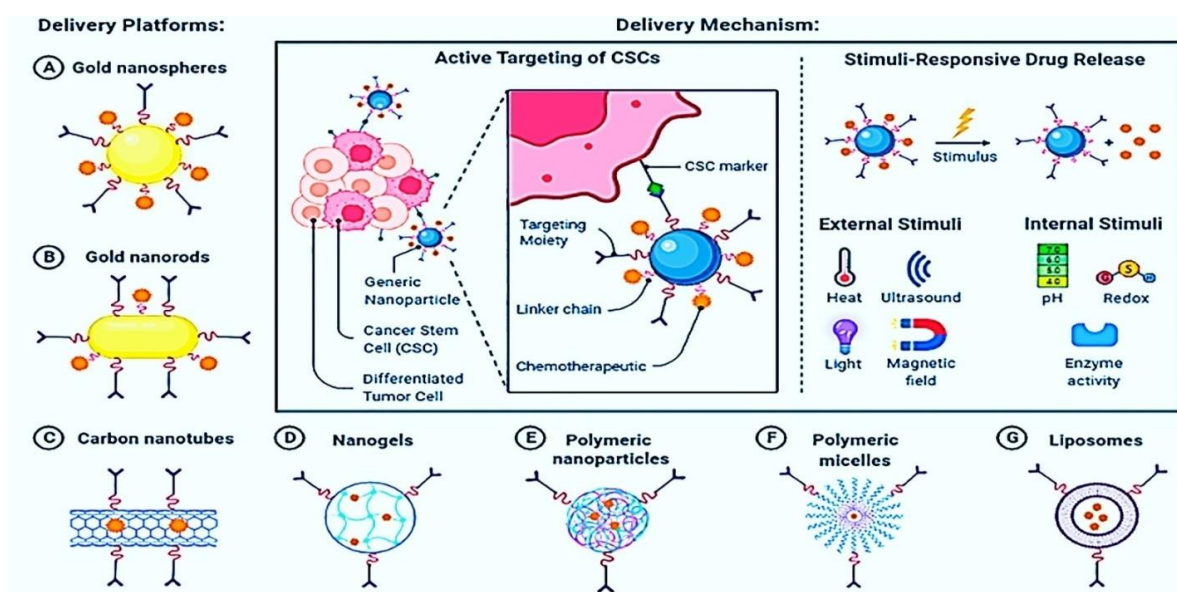


Figure 1: Nanoparticle-mediated targeted drug delivery to cancer cells.

ROLE OF NANOPARTICLES IN VARIOUS TYPES OF CANCERS

Cancer is one of the significant public health problems globally and is the second leading cause of death. According to the American Cancer Society, the number of new cases is anticipated to be 2.0 million by the end of the year 2023. With its intricate pathophysiology, cancer is one of the most common causes of mortality and morbidity. Chemotherapy, radiation therapy, targeted therapy, and immunotherapy are examples of conventional cancer treatments. Nevertheless, obstacles like cytotoxicity, lack of selectivity, and multidrug resistance provide a significant obstacle to effective cancer treatment. The field of cancer diagnosis and treatment has undergone a radical change with the

development of nanotechnology. Because of their unique benefits, which include improved permeability and retention impact, less toxicity, more good stability, and accurate targeting, nanoparticles (sizes ranging from 1 to 100 nm) can be utilised to treat cancer. The unique nanoparticle drug delivery technique makes use of the properties of the tumour and its surroundings. Nanoparticles overcome multidrug resistance in addition to the drawbacks of traditional cancer treatment. New avenues for the therapy of cancer have been opened up by the therapeutic implications of nanoformulations. Nevertheless, the majority of research is restricted to in vivo and in vitro investigations, and the quantity of authorised nanodrugs has not increased significantly over time.

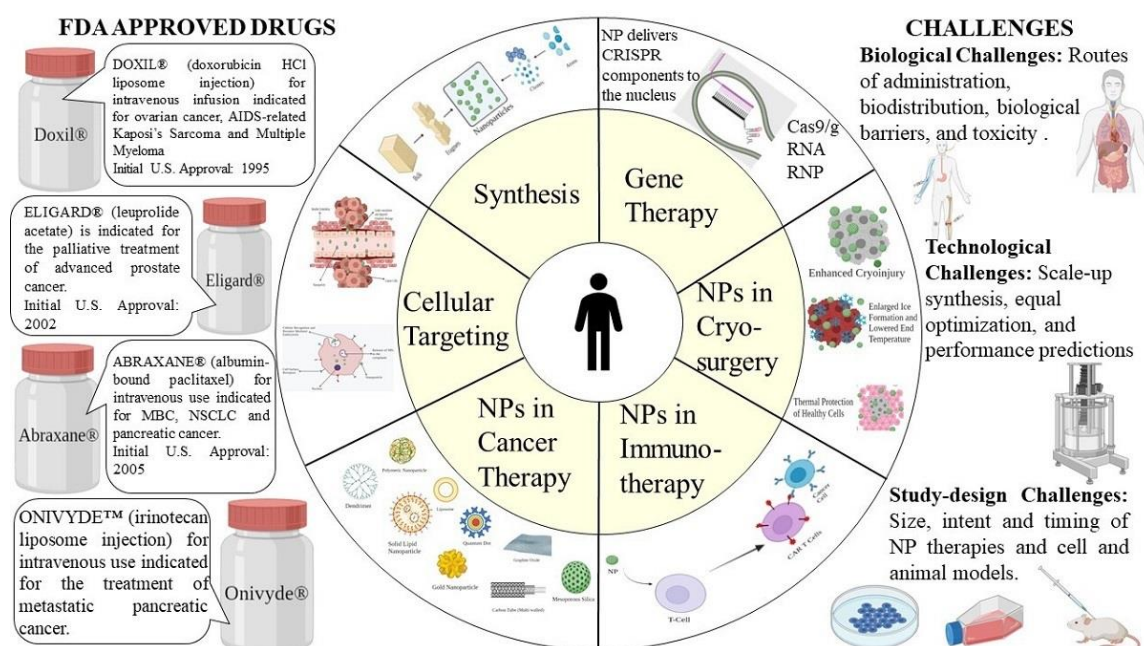


Figure 2: Diagrammatical representation of nanoparticles for cancer therapy.

Mohammad Zaki Ahmad *et al.*, 2022 revealed that, the development of nanoscience makes it possible to target cancer cells in a precise and selective manner. Hydrophilic and lipophilic chemotherapeutic agents, proteins/peptides, and other genetic elements can all be enclosed by chitosan nanoparticles. By regulating the release rates and the method of targeted distribution, chitosan nanoparticles can enhance the pharmacokinetic profile as well as the therapeutic effectiveness of encapsulated medicines. Through passive or active targeting processes, these nanoparticles distribute the medications they contain just to the desired areas, reducing any negative side effects. To accomplish selective targeting, the surface of chitosan nanoparticles can be altered with a variety of ligands, including antibodies, proteins, peptides, polysaccharides, and nucleic acids. With regard to recent advancements in chitosan-nanoparticles for intelligent anti-cancer therapeutic delivery, this review will offer a state-of-the-art perspective.^[44]

Sharifi-Rad J *et al.*, 2021 has studied on popular anticancer drug called paclitaxel is made from yew tree bark. Against several tumors, it has demonstrated antitumor efficacy. Due to its toxicity, low solubility, and propensity for recrystallization, its use is problematic. The use of nanotechnology and nanoparticles has benefits such as improved medicine distribution, less toxicity, and longer drug half-lives. Nanodrugs can reduce toxicity in normal tissues while increasing permeability, retention, and anticancer effects.^[45]

Sharifi-Rad J *et al.*, 2021 has examines the use of chitosan-based nanoparticles in medical applications. It emphasizes their significance in drug development, biomedical engineering, and nanomedicine. Improved bioavailability, enhanced selectivity, and decreased pharmacological toxicity are all results of recent investigations. The study emphasizes the potential of nanoparticles made of chitosan for anticancer medication delivery systems.^[46] **Tagde P *et al.*, 2021** Breast cancer is a common condition that frequently results in mutations of the estrogen/progesterone receptor. Due to worries about low bioavailability, resistance, and toxicities, traditional treatments including surgery, radiation, and chemotherapy are ineffective. A viable alternative for enhancing therapeutic efficacy and minimising negative effects is nanomedicine-based methodology. This research examines current methods and difficulties in suggested nano-enabled medicinal techniques.^[47] **Liu S *et al.*, 2021** Chemotherapy's therapeutic impact is restricted by multidrug resistance (MDR), a problem that persists in the cancer community. The use of multifunctional nanoparticles, which remain stable in blood circulation and accumulate specifically in the tumor microenvironment, may be a potential strategy for reversing MDR. The synergistic effects of chemotherapy and ABC transporter inhibitors, the use of nanoparticles to evade efflux transporters and target organelles associated with resistance, and the combination of several treatment modalities are the three

basic approaches. Drug resistance has been demonstrated to be closely related to cancer stem-like cells (CSCs).^[48]

Castilho ML *et al.*, 2021 has studied, in order to cure triple-negative breast cancer, the study investigates the use of bifunctional theranostic nanoprobes (BN). It was discovered that the BN, functionalized with Chlorine and Epidermal Growth Factor, was extremely cytotoxic to cancer cells, inducing apoptosis and necrosis and efficiently causing targeted cell death.^[49]

Damasco JA *et al.*, 2021 Nanomaterials are used in nanomedicine to diagnose, cure, and prevent diseases like cancer. However, inorganic materials provide difficulties due to safety worries and inherent toxicity. The stability, circulation time, bioavailability, and safety profile are key factors in clinical translation success. The focus of this study is on the rational design of non-toxic/safe nanoparticle structures while it includes preclinical and clinical nanomaterials utilized for cancer imaging and therapies.^[50]

Li YJ *et al.*, 2020 has investigated the highly metastatic pancreatic cancer has a dismal prognosis and rising fatality rates. Through the use of nanomedicine, it is possible to stop the spread of cancer by targeting cancer stem cells, the tumor microenvironment, circulating tumor cells, and tumor exosomes. In order to improve treatment results in the future, research on metastasis prevention is essential.^[51]

Vander Meel R, *et al.*, 2019 revealed the treatment of cancer makes substantial use of nanomedicines. Here, we suggest four strategic strategies to enhance the translation and application of nanomedicine. (1) Patient stratification is now a standard procedure in the development of cancer drugs. In order to find people who are qualified for inclusion in clinical trials, cancer nanomedicine urgently needs probes and methods for patient stratification. (2) Effective clinical and commercial medication selection is essential. (3) The cornerstone of clinical cancer treatment is combination therapy. Nanomedicines work in conjunction with pharmacological and physical co-therapies, hence they should be included in multimodal combination therapy plans more frequently. (4) Immunotherapy is transforming how cancer is treated. Nanomedicines can alter the behaviour of myeloid and lymphoid cells, enhancing anticancer immunity and the effectiveness of immunotherapy.^[52]

Chen WH *et al.*, 2019 has developed the development of a functionalized AuNP-based therapeutic system that can uniquely respond to the tumour microenvironment has been reported as a novel approach. In the therapeutic approach, doxorubicin was attached to AuNPs via a thiol-Au link by using the protease's particular peptide substrate, CPLGLAGG. In vivo research demonstrates that the overexpression of MMP-2 protease in tumour tissue and intracellular GSH can cause the rapid release of the anti-tumor drug (doxorubicin) from the functionalized AuNPs to simultaneously inhibit tumour growth and enable fluorescent imaging. The tumor-triggered medication release feature of the functionalized AuNPs can further increase efficacy and drastically reduce negative effects.^[53] **Wolfram J *et al.*, 2019** has studied about the

cancer therapies using nanotechnology have increased effectiveness and safety. Due to their enormous size and high surface area to volume ratios, nanoparticles can be employed therapeutically. These particles have unique transport, biological, optical, magnetic, electronic, and thermal characteristics. In addition to imaging, targeting, and triggered activation, they can support a variety of therapeutic tasks such as immunoevasion and tissue penetration. The body processes nanoparticles differently, which improves medication delivery. Companion diagnostics, modifying the microenvironment, and using extracellular vesicles for

medication administration are some of the future objectives in nanomedicine.^[54]

ROLE OF NANOPARTICLES IN CANCER IMMUNOTHERAPY

The T cells become activated and transform to CTLs. The CTLs can attack tumor cells via direct killing or IFN- γ dependent pathways. (1) NPs modified with antigens and adjuvants specifically deliver antigens to DCs, (2) and promote DCs maturation and CTL activation by antigen presentation or the assistance of adjuvants.

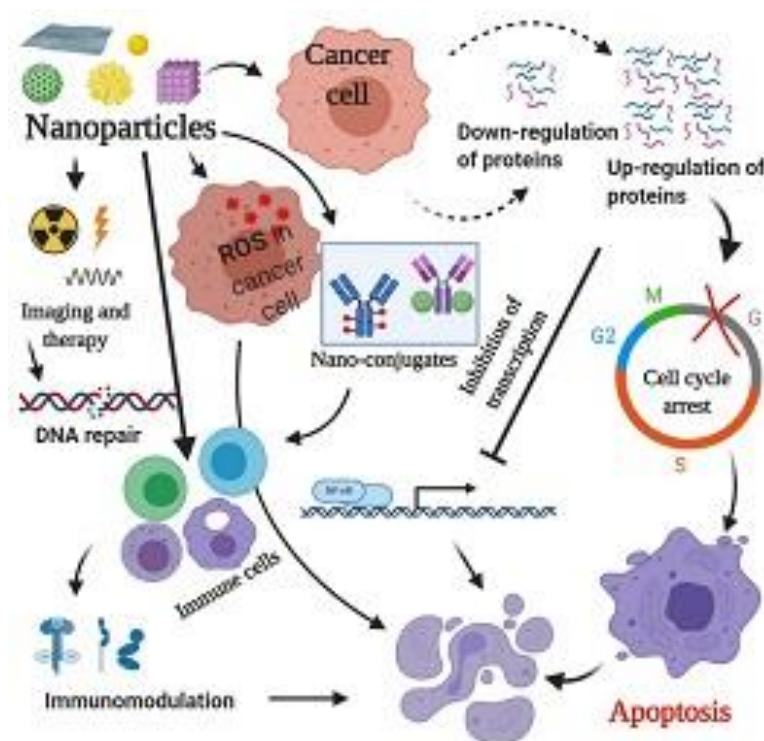


Figure 3: Diagrammatical representation of nanoparticles for immunotherapy.

Lakshmanan VK *et al.*, 2022 reviewed the rapid advancement of cancer nanomedicine has propelled immunotherapy's results to the next level in the current era of medical research. This review focuses on key findings regarding the efficacy of nanomedicine-based cancer immunotherapies and their applications, including immune checkpoint inhibitors and nanomedicine, CRISPR-Cas nanoparticles in cancer immunotherapy, core-shell nanoparticles in combination with cancer immunotherapy, biomimetic NPs for cancer immunotherapy, and CAR-T cells and cancer nanoimmunotherapy. Different facets of the proposed nano-enabled therapeutic techniques have been examined in this review by analysing the state-of-the-art technologies and taking the challenges involved into consideration.^[55] Zhang P *et al.*, 2019 Even after thorough treatment, metastatic disease is the main cause of death from cancer. Due to its capacity to modify the immune system, immunotherapy has demonstrated promise in the treatment of cancer. In order to prevent tumour metastasis and increase animal longevity,

nanomedicine efforts have been centred on using immune cells that are engaged in the metastatic. In this expanding subject, recent tactics and nanomaterials are emphasised.^[56] Irvine DJ *et al.*, 2020 has studied the chimeric antigen receptor T cell therapy and checkpoint blockade antibodies have both proven effective in the treatment of cancer. However, the limited effectiveness and toxicity of novel immunotherapy drugs and therapies present difficulties. Nanomedicines are highly suited for immunotherapy because they can target Immunomodulators to tumors and lymphoid organs, increasing treatment absorption and decreasing off-target damage.^[57] Rosenberg SA *et al.*, 2008 has investigated the tumor microenvironment (TME) is a sophisticated ecology that includes immune cells, fibroblasts, blood vessels, and tumor extracellular matrix. The biggest immune cells in the TME, tumor-associated macrophages (TAMs), have an impact on tumor development, invasion, metastasis, angiogenesis, and immunosuppression. Drugs that target this control can be created using TAM polarization, possibly improving the

effectiveness of tumor treatment. Recent developments in nanomedicines specifically target TAMs, preventing macrophage recruitment and repolarizing them to improve the effectiveness of cancer treatment.^[58] **Soetaert F *et al.*, 2020** has demonstrated Cancer nanomedicine promise in terms of enhancing cancer therapy, however there is a view that the quantity of licensed products and clinical effectiveness are limited. With a lengthy history in medicine, iron oxide nanoparticles have been used for iron deficient anemia treatment, hyperthermia therapy, and cancer diagnostics. Clinical experience with IDA parenteral treatment with liposomal drug delivery demonstrates safety and adaptability. Cancer treatment employing magnetic hysteresis heating, magnetic fluid hyperthermia, finds it difficult to gain clinical traction. Recent studies have revealed the potential of immune modulation, stressing the need for new paradigms and interdisciplinary strategies in the development and application of nanomedicines in clinical cancer treatment.^[59] **Irvine DJ *et al.*, 2020** Chimeric antigen receptor T cell therapy and checkpoint blockade antibodies have both proven effective in the treatment of cancer. However, the limited effectiveness and toxicity of novel immunotherapy drugs and therapies present difficulties. Nanomedicines are highly suited for immunotherapy because they can target Immunomodulators to tumors and lymphoid organs,

increasing treatment absorption and decreasing off-target damage.^[60] **He YC *et al.*, 2023** has studied through the cancer immunity cycle, drug delivery systems (DDS) have improved cancer immunotherapy, revolutionizing medicine. Therapeutic payloads can be delivered into the body via genome editing technology. To improve cancer therapy methods, an MITO-Porter focuses on delivering macromolecules directly to the mitochondria of cancer cells. There is additional discussion of the effects of regulated intracellular trafficking.^[61] **Melero I *et al.*, 2014** has studied the traditional chemotherapeutic medications are ineffective at treating colon cancer because they don't target the disease specifically and have harmful side effects. Nanomedicines with multimodal therapeutic approaches, such as chemotherapy, radiation, phototherapy, chemodynamic therapy, gas therapy, and immunotherapy, have the potential to cure colon cancer.^[62]

ROLE OF HERBAL NANOPARTICLES CANCER THERAPY

Polylysine dendrimers have the potential to be biodegradable carriers and deliver cytotoxic drugs to solid tumors. Drug resistance, toxicity, and the mechanics of drug release in capsules can all be overcome using dendrimers, which make them ideal systems as smart nanoparticles for cancer therapy.

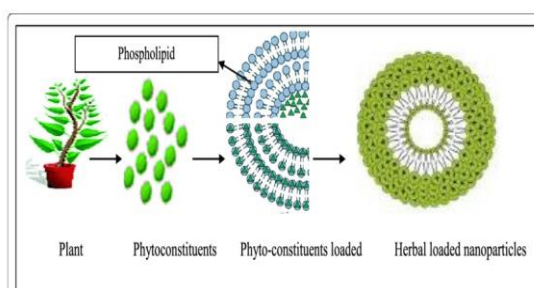
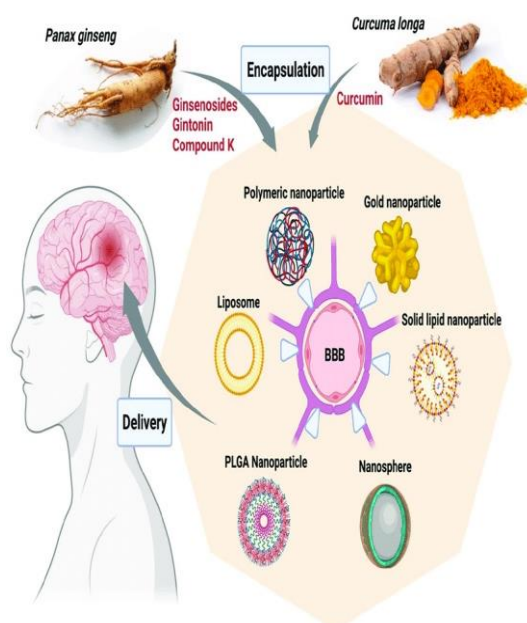


Figure 4: Diagrammatical representation of herbal nanoparticles cancer therapy.

Bonifácio BV *et al.*, 2014 has studied the chemotherapy, hormone therapy, and gene therapy are just a few of the cancer therapies that might be significantly improved by herbal chemicals. They can influence signal transduction pathways, lessen side effects, and prevent medication efflux, and they are safer and less toxic than synthetic versions.^[63] **Lacouture M *et al.*, 2018** has investigated, throughout human history, natural items have been employed as herbal remedies, and they currently play a big role in healthcare. They may be used as therapeutic

agents to treat conditions including Alzheimer's, cancer, and inflammation. Due to limited bioavailability, their clinical trials have had less success. Natural products may be better absorbed and delivered to target areas when they are in nanoformulations. Particles can be manipulated by nanotechnology to target certain locations and regulate medication release. Future advancements in biomedicine, notably in the area of cancer treatments, may be driven by this discipline. This

article summarizes recent developments in nanoparticle delivery technologies for biomedical purposes.^[64]

CONCLUSION AND FUTURE PERSPECTIVE

Through the delivery of tiny molecules for cancer detection, diagnosis, and therapy, nanotechnology has demonstrated a promising new era in cancer treatment. Numerous cancer types are being treated extensively in clinical settings using cancer therapies based on the unique characteristics of NPs. NPs offer a great foundation for combination therapy, which aids in the treatment of multidrug resistance. Numerous NP forms, including metallic, hybrid, and polymeric NPs, have demonstrated increased drug delivery efficacy as a result of increased study. There are some restrictions, nevertheless, including the lack of in vitro models that accurately represent the in vivo stage, immunotoxicity, long-term toxicity, and neurotoxicity. The clinical efficacy of "nanovaccines" and "artificial APCs" remains subpar, despite their demonstrated superior efficacy over traditional immunotherapy. It is necessary to examine these novel modalities' tolerance and safety. Furthermore, creating "immunomodulatory factor-loaded NPs" could improve vaccine efficacy for immunotherapy. More work needs to be put into "understanding toxicity, cellular and physiological factors that regulate NP-based drug delivery, EPR, and PC mechanism" in the human body in order to develop nanotechnology rationally. We assume that the development of nanotechnology and cancer therapy will bring about a revolution in the clinical translation of NP-based cancer therapy, based on the findings mentioned above.

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