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Research Article

The Importance of Nanotechnology in Modern Medicine and its Use as Antimicrobial and Anticancer: a review

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Abstract:

Therapy utilizing nanoparticles has become known as a promising therapeutic modality. Those nanoparticles' nanosized gives them certain physical and chemical features as well as improves how well they interact with the biological system. Nanomaterials are characterized by treating many diseases, such as the treatment for cancer along with the significant issue of drug resistance in infection control. Incorporating antimicrobial Nano compounds into materials to prevent microbial adhesion or kill microorganisms has become an increasingly challenging strategy. Recently, many studies have been conducted on the preparation of nanomaterials with antimicrobial properties against diseases caused by pathogens. Despite tremendous efforts to produce antibacterial materials, there is little systematic research on antimicrobial coatings. In this article, we set out to provide a comprehensive overview of nanomaterials-based antimicrobial coatings that can be used to stop the spread of contamination on surfaces. Because of these particles' unique size, shape, and range of fundamental and chemical behaviors, they are being utilized to enhance current treatments. Together with a thorough overview of the condition of nanotechnology in medicine today, the writers covered the application of nanoparticles in the treatment of cancer, illnesses brought from bacteria that are resistant to drugs, including biofilm prevention.

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Introduction

Main creation, employ, along with modification of substances with a range of nanometers are among the topics of a branch of study called nanotechnologies (1). For the purpose of to create nanoparticles with particular processes, nanotechnologies combines physical (size, shape, lamellarity, and homogeneity), chemically (composition,temperature surface charge, surface coating, and phase transition), and biological in nature (expressed substances as well as attached exterior the ligands) fundamentals (2,3). The English phrase "nano" comes from the Greek word "nanos," meaning signifies little and is used as a prefix for one billionth of a component (10^{-9}).

The unique optical, magnetic, and catalytic capabilities of metallic nanoparticles have sparked a great deal of curiosity. To modify these properties, the particle size, shape, and mono-dispersity are crucial (4). Main creation, employ, along with modification of substances with a range of nanometers are among the topics of a branch of study called nanotechnologies (1).

For the purpose of to create nanoparticles with particular processes, nanotechnologies combines physical (size, shape, lamellarity, and homogeneity),chemically (has surely affected every field of research and development. Because of their improved qualities and performs that greatly contrast with those of their bulk counterparts, the nanoscale materials and frameworks have been investigated for an extensive variety of life sciences uses, which include biological products separateness, delivery of medications, gene therapy for cancer treatment, imaging of molecules, as well as biological detection (5).

Nanoparticles

Colloidal fragments, sometimes referred to by the term nanoparticles that have been bonded either adsorption with their outermost portion, or they possess a medicinal ingredient that is intriguing linked to their polymeric matrix (6). The previously distinct physiochemical characteristics of metallic nanoparticles, including their elevated surface-to-volume percentages, their simplicity in functionalization by means of simple chemical science, as well as the spectrum and visual qualities, have attracted the attention to basic researchers to feed a range of the technological and therapeutic applications (7). Because of their small size, nanoparticles may communicate between macromolecules on their outermost layer as well as within cell membranes in medical treatment, improving outcomes, reducing toxic relationships, and achieving target specificity. As an illustration, consider the use of gold nanoparticles in determining the presence of genetic issues, treatment with photothermal therapy, and tumor detection (8).

Silver Nanoparticles

Whenever ethanol treates silver ions at temperatures between 800 and 1000^{0}C in an ambient atmosphere, nanoparticles of silver are produced. Those are type particular kinds of nano that are most frequently employed. These are utilized throughout textile manufacturing sunburn creams as well as purifying water because of them potent antibacterial capacities (9). Species that can biosynthesize appropriate quantities of nanoparticles of silver include The capsicum annuum, Carica papaya, and Azadirachta indica (10).

Gold Nanoparticles

A fluid chemistry procedure called eliminating hydroauric acid ($HAuCl_4$) yields nanoparticles of gold (11). Proteins are used in protein-protein interaction identification as well as immunochemical investigations. In addition, enzymes are employed within the detection of aminoglycoside drugs such as a drug called, streptomycin, and gentamycin, along with DNA in a fingerprint specimen. The gold nanorods can also identify stem cells from cancer and a number of bacterial pathogens (12).

Copper Nanoparticles

Whenever subjected to electromagnetic irradiation a novel technique called copper sulfate reductions using hydrazine in ethylene glycol produces nanoparticles of copper (11). The amount that is present of polyvinyl greatly affects the dimensions of copper nanoparticles; increased levels result in particles that are smaller. They fall essentially in the range of 1 and 100 nanometers in size. They may be used with both biological products and electrochemical detectors. Bykkam and Ahmadipour (12) claim that they also function as antifungal or antibacterial agents.

Synthesis of Nanoparticles

Nanoparticles can be produced chemically or organically. Because of the numerous dangerous compounds absorbed on the outermost layer, the substance manufacturing procedure was linked to a number of negative outcomes. The processes associated with biological production involve the employment of microorganism's proteins, plants, fungi, or extracts from plants (13). Materials like polysaccharides, proteins, along with polymers that are synthetic can be used to make them. An additional component that helps fungi generate external nanostructures is large secretory elements (14). A number of different variables affect the choice for matrix substance, including the dimensions of the particles nanoparticles the intrinsic properties about the medicament, soluble as well as stability within fluid, charge, permeation, degradation, biocompatibility, toxicity, release of medication, as well as antigenic properties of the end result (15).

Medical Applications of Nanotechnology

Increased disease diagnosis, detection at an early stage, and preventative measures are supported by nanotechnology. DNA sequencing became easier through the introduction of nanotechnology technologies, including gold nanoparticles. These additionally serve to detect mutations whenever paired with these tiny portions of DNA. Tissue that has been injured may be replicated or repaired thanks to nanomaterials. Nanotechnology has the potential to alter the transplant of organs as well as prosthetic placement (16). However, quantum dots have been utilized for embryonic cell monitoring, and imaging of molecules, among other fields. It is possible to regulate stem cell development and differentiation by using specially made nanoparticles (17).

The Central Nervous System's rejuvenation as well as neural protection are two further advantages using nanomaterials. Among the many renowned neurological conditions is Parkinson's illness. These extracellular nano-enabled scaffolding devices (NESD) provide a wonderful way to deliver location-specific dopaminergic injections into the brain, reducing the peripheral adverse reactions of Parkinson's disease medicines. Activating communication pathways across controlled axon growth and using peptides and peptidic nanoparticles as ground-breaking medicines for a range of CNS illnesses are two instances of innovative tactics.

. Furthermore, they additionally have the capacity to restore completely injured cells, protecting the brain along with facilitating the passage of medications and chemicals throughout the blood- brain barrier. Alzheimer's disease patients' brains contain the bulk of amyloid beta plaques (18). With their important attraction towards plaques, and these tiny particles may lessen their presence and the associated symptoms of

Alzheimer's disease. One respiratory illness that can be fatal is tb.

The latest advances in nanotechnology are enhancing the efficacy and economic viability of malaria pharmacology by encapsulating as well as releasing antiTB drugs. Nano filled composite resin materials offer excellent tear rebellion hardness and exceptional cosmetic qualities on par with operational dental due to such exceptional shine preservation as well as polishability. During proactive dental care, sphere silicon oxide nanofillers may change the amount of inorganic phase that is available. Those nanocomposite substances exhibit exceptional flexibility low polymeric shrinkage as well high bending endurance, with extreme rigidity (19).

For eye disease, nanomaterials are also used in prosthetic devices, gauging intraocular pressure in the eyes, repairing choroidal new blood vessels, minimizing fibrosis following ophthalmology an operation, and lowering oxidative stress in the body (20). Recently, distributed eye ointment (NDEO) based on nanomaterials has been successfully used for the management of extreme excessive eye irritation. A histopathological investigation revealed that NDEO56 recovered the typical ocular as well as conjunctive structure. By using zinc oxide nanoparticles, resistance to antibiotics can be reduced and ciprofloxacin's antimicrobial effects on microorganisms can be strengthened. Such is what happens when the nanoparticles engage with protein molecules which generate resistance to common antibiotics. Through inhibiting the breakdown of histamine through mast cells into the blood and organs, overall nanodevice known as buckminster fullerenes, or "bucky balls," can alter the immune system's reaction (21).

By reducing some of the unwanted systemic side effects, using nanopharmaceuticals enhances compliance among patients. These play an essential role for comprehending whether traditional medications designed toward chemical compounds at certain sites are ineffective. Thrombocytic medications according to nanoparticle might possess an enhanced ability to break apart clots. With nanodentistry, nanotechnology is potentially utilized to correct each the affected teeth's orthodontic treatment, discover a permanent remedy for sensitivity, and achieve additional therapeutic objectives. Computer-controlled nanorobots have the potential to eliminate dental caries-causing microorganisms and restore teeth with decaying areas (22).

Limitation of Nanotechnology

One major drawback associated with nanomaterials is their ability to remain unnoticed within the surroundings after discharge, which might cause problems when cleanup is necessary. development of instruments for analysis is necessary to detect nanomaterials within the natural world. It takes enough information to understand the connection of surface space chemical potential as well as the functionality as well as toxicities of nanomaterials. There may be a risk of coming into contact while using or producing novel nanoparticles. such as, careful danger assessments need to have been considered. When the rare material requirements are being utilized to make nanoparticles that a successful reuse and recycling strategy is needed. Consequently, to improve threat assessment, additional studies must bridge the enormous knowledge gap in nanotoxicity (23).

Antibacterial properties of nanoparticles

Currently, among the most pressing issues is the spread of bacterial antibiotic resistance to alternative antibiotics. First, as in the case of several drug-resistant *Staphylococcus aureu*s (MRSA), bacteria have a genomic tolerance to antibiotics; second, biofilms that are both strongly adhering and antibiotic-resistant are formed. These events are the fundamental causes of antibiotic resistance. The development of innovative therapies that might solve such problems is therefore crucial. As a superior alternative to traditional antibiotic therapy, nanomaterials have a unique mechanism of action and strong antibacterial properties [24, 25] additionally was demonstrated that metallic nanomaterials are poisonous to bacterial in a way that is not present in the cells of mammals. subsequently is commonly acknowledged that nanoparticles may bind with the microbe cell wall and then cause a harmful impact through disrupting the porous nature of the cell wall of the bacterium, even if the precise mechanism underlying this selectivity remains poorly understood yet. These biological functions could be additionally susceptible to the electrically charged particles that iron nanoparticles produce [26]. Additionally, one among the primary processes beneath the antibacterial action of nanoparticles is the generation of harmful reactive oxygen species (ROS) including superoxide, peroxide of hydrogen, and hydroxyl ions, among others [25, 27]. There are two primary broad groups of nanoparticles utilized in antimicrobial therapy, according to their chemical structure. suppression of biofilms .Biofilms are sticky are characterized as sessile, surface-adherent bacterial populations submerged within a solution of self-produced polymer matrix [28]. Bacterial surface adhesion, cell multiplication, matrices creation, then separation are the stages that occur in the development of biofilms (Fig. 1). The habitat that the biofilms produce strengthens bacteria resistance. Nanoparticles are known to interfere with the production of biofilms as well as toPossess a direct antibacterial effect [27].

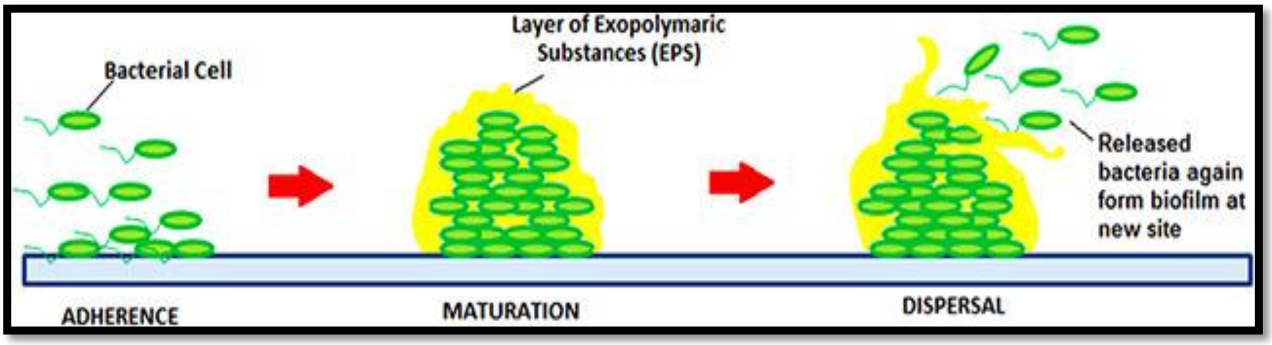

Fig 1: Stages of biofilm formation by bacterial cells

Nanotechnology has a chance to either inhibit the creation of new biofilms being formed or eradicate existing ones. Numerous separate research on the application of nanomaterials to suppress biofilms are now underway; a few of the more notable ones are featured in this overview. Zerovalent bismuth nanoparticles were demonstrated to completely suppress the growth of S. mutans biofilms [29]. These devices treated with magnesium fluoride nanoparticles efficiently inhibited the development of the biofilms across the growing medium and physiologically important liquids, according to a study [30].

Zinc oxide/graphene nanotechnology was demonstrated to suppress S. mutans biofilm, which is and their protective coating is being suggested as a defense against cariogenic S. mutans biofilm on implants in the mouth. By keeping amazing cells reliability, the novel category of extremely thin (~1-2 nm) silver ring-coated nanoparticles containing Super paramagnetic iron oxide (SPIONs) with ligand gap demonstrates antimicrobial agents features toward microorganisms additionally, SPIONS showed an elevated therapeutic efficiency regarding diseases brought about by bacteria such *as S. aurous* and *S. skin* [31]. Kulshrestha et al. [32] described the use of calcium fluoride nanoparticles to stop S. mutans from forming biofilms during the early phases of the infection. Another way that nanomaterials can be utilized for enhancing photodynamic treatment is to use an innovative treatment method to get rid of biofilms over time It has been established this type I phototoxicity, a hydroxyl free radical, constitutes the mechanism whereby the gold nanoparticle–methylene blue conjugate inhibits the growth of Candida albicans . Gold nanoparticles were utilized to augment methylene blues-induced photodynamic treatment [33]. A separate investigation demonstrated that erythromycin in its natural state does not considerably suppress biofilms of microbial species as much as erythrosine incorporated into chitosan nanoparticles for the use of photodynamic therapy [34].

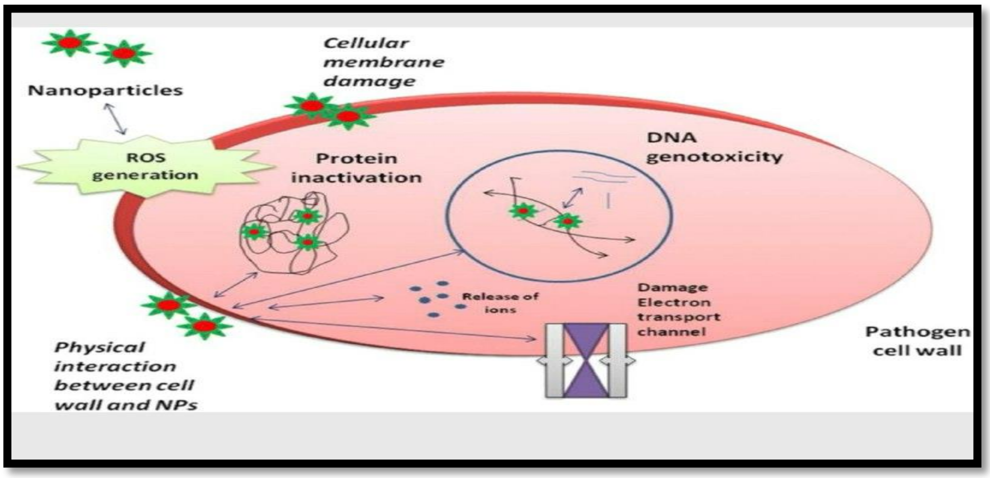

Fig2: Mechanism of action of nanoparticle in bacterial cell (35)

Table 1 summarizes a few of the most current studies regarding the use of nanomaterials as anibacterial and antibiofilm agents in a variety of ways. Considering what has been said previously mentioned, it might be inferred how nanoparticles have attracted a lot of interest as antimicrobial as well as antibiofilm substances in addition to being a possible contender during anticancer therapy.

Table 1 : An overview of a few current studies on the application of nanoparticles as agents against bacteria and biofilms

Type of nanoparticles	Microorganism
liposome loaded with ampicillin	*S. typhimurium, L. monocytogenes*
liposome encapsulated penicillin	*P. aeruginosa*
PLGA encapsulated azithromycin	*S. typhi*
chitosan nanoparticles	*S.aureus, E. coli*
quaternary ammonium polyethylenimine nanoparticles	*S. mutans*
AgNPs	broad range of microbes
zinc oxide nanoparticles	broad range of microbes
CuONPs	broad range of microbes
magnesium fluoride nanoparticles	*E. coli, S. aureus, S. mutans*
gold nanoparticles functionalised ampicillin	*P. aeruginosa, E. aerogegenes*
graphene oxide silver nanocomposite	broad range of microbes, *P. aeruginosa* biofilm
zero valent bismuth nanoparticles	*S. mutans* biofilm
graphene/zinc oxide nanocomposite	*S. mutans* biofilm

It's critical to understand the safety problems associated with using inorganic nanoparticles immediately in the natural cells of mammals as an antibiotic. to show whether the amount of nanoparticle used for antibacterial therapy is safe with ordinary cells in mammals, cytotoxicity tests are conducted using lineages containing human cells that function normally. For instance, HEK-293 cells (human embryo kidney cells) served throughout a research by Kulshrestha *et al.* to conduct a cytotoxic experiment. The doses of

CaF2 NPs employed in the experiment are shown to be not cytotoxic to HEK-293 cells. While data collected in vitro may not necessarily convert into a systemic degree of exposure, in vivo investigations are still required to determine the harmful effect of nanoparticles. If taken in person, the nanoparticles may also have the adverse consequence of upsetting the host's gut microbiome's equilibrium. The material now in publication does not indicate if those relationships take place or if they are beneficial, negative, or insignificant. Therefore, while employing nanotechnology in treatments, more study within this field is needed [32].

Recent advances in the field of nanomedicine

The science of nanotechnology is expanding rapidly yet has a significant influence on human health. A variety of products and nano formulations that aid in the management of infectious illnesses including cancer are currently under development as a result of studies an advancement in this field of study. Numerous items remove on nanomedicine have received FDA approval or are undergoing clinical trials. Twelve more liposome-based medicines have been developed as a result of liposome investigation, including DOXIL, the initial approved by the FDA nanomedicine. Additionally, thirty lipid-based nanoformulations are being studied clinically. The liposomal version of doxorubicin, known as DOXIL, is specifically utilized in the management of cancer., Due to a global scarcity of DOXIL following the invention's breathing out, the FDA authorized an alternate version of DOXIL called Lipodox. The mechanism of action of lipodox and DOXIL are comparable [36, 37]. Another doxorubicin liposomal platform undergoing clinical studies is ThermoDox (Celsion Corp.). During elevated temperatures, the sensitive to temperature liposome produces doxorubicin. A medication has been researched for the management of cancer of the breast relapse on the wall of the chest including liver metastases [37]. A dual-agent liposomal combination of a chemotherapy drug such with a combination called CPX-351 (Celator Pharma), showed an intriguing efficacy versus hematologic cancers. There are preliminary studies for this. Small interfering RNAs (siRNAs) and therapeutic gene medicines were two examples of DNA compositions encapsulated both liposomes that have recently been investigated within experimental and medical settings regarding their potential to cure cancer [38].

The FDA also approved for protein nanoparticles as medicines. One example was Abraxane, ABI-007 (Abraxis Corporation), an albumin-bound, solvent-free drug called paclitaxel. A chemotherapeutic medication with FDA approval, paclitaxel is employed in treating a variety of solid cancer, including ovarian, lung, gastrointestinal, and breast malignancies. Abraxane is a solution of 130 nm particles that break through the blood plasma into about 8 nm paclitaxel-coated protein molecules [37]. Comparing the medication separately with medication conjugated nanoparticles of polymers, which are drugs coupled to an additional polymeric material, shows promise within the therapy of disease. Numerous a combination has been studied in both preclinical and clinical environments. paclitaxel is a polyglutamic acid paclitaxel nanoconjugate manufacturing that is marketed beneath the trademarked name Xyotax (which was subsequently changed to Opaxio) (CTI Biopharma). subsequently is undergoing trials and is currently proposed just like an alternative therapy for ovarian and lung cancer that is not small cell carcinoma [39]. HPMA (N-(2-hydroxylpropyl) methylacrylamide) polymeric doxorubicin is an additional possible instance. It successfully finished preliminary research on malignancies of solid cancers that have metastasized. PK1 (Pfizer Inc.) is its trade designation [40]. Furthermore, a plethora of additional nanomedicines in recent including NK012 (Nippon Kayaku Co. Ltd.), SP1049C (Supratech Pharma Inc.), BIND-014 (Bind Therapeutics), as well as several more, are undergoing varying levels of clinical studies. In addition to medication administration, of several inorganic nanoformulations are being investigated for applications in imaging. For example, SPIONs are undergoing clinical studies to help visualize tumors and malignancies [37].

Numerous nanomedicines have been created and employed for the treatment of microbiological illnesses. Several nanomedicines are undergoing research investigations or have FDA approval. The process of clinical translation is difficult. This includes extensive preclinical investigation, carefully chosen therapeutic results, suitable clinical trial approach as well as effective study accomplishment [37]. The Food and Drug Administration (FDA) has licensed nanoliposomes such (Gilead Sciences, Inc.) and DepoCyt[e] (Pacira Pharmaceuticals, Inc.) for use in the management of microbiological illnesses. a nanoliposome loaded with cytarabine, AmBisome is filled with amphetamine. The Food and Drug Administration (FDA) allowed phospholipid nanoparticle formulations including MEGACE ES (Par Pharmaceutical Organizations, Inc.) and Amphotec (Sequus Pharmaceuticals, Inc.), which are lipid nanoparticles packed alongside acetate of megestrol and amphotericin, respectively. With its composed of water gel formulation and vaginal delivery, the nanodendrimer (VivaGel, Starpharma Holdings Limited) is currently approved by EU regulations to provide topical drugs with rapid alleviation of vaginosis caused by bacteria [41]. Additionally, a number of investigations on nanoparticles that are inorganic as antibacterial agents exist; this research requires translation into use in medicine.

Nanotechnology in imaging and diagnosis

One of the most important stages in the medical procedure is making a diagnosis. All diagnosis should be made as quickly, precisely, and specifically as possible to avoid "false negative" situations. A non-invasive method called "in vivo imaging" can detect symptoms or indicators inside a patient's living tissues without requiring surgery (42). Using biological markers to identify cellular changes in tissues has been a prior advancement in diagnostic imaging methods. Utilizing a biological marker as a technique for early detection aims to identify diseases or symptoms (43). Notably, nanotechnologies have been used in the development of several of these very precise molecular imaging agents. Imaging is essential not only for diagnosis but also for identifying possible hazardous responses, assessing medication distribution in the body, conducting controlled drug release studies, and closely tracking the course of a treatment. By releasing the medicine when needed and keeping an eye on how it distributes throughout the body, potential drug toxicity can be minimized. (44).

Diagnostic imaging

Imaging methods which are well-established and often utilized in biochemical and medical investigations include computed tomography, magnetic resonance imaging, ultrasound, nuclear medicine, and X-rays. Although it might be enhanced by using contrast and targeting agents utilizing nanotechnologies that enhance resolution and particularity by indicating the area of infection at the tissue level, these techniques can only examine changes on the tissue surface relatively late in the progression of the disease (45). The majority of medical imaging contrast agents now in use are tiny compounds with a rapid metabolism and non-specific distribution, which increases the possibility of harmful side effects. (46). Because nanoparticles have improved permeability and retention effects within tissues and decreased toxicity, they have the potential to generate more effective contrast agents for nearly all imaging modalities. This constitutes the area in which nanotechnologies have the greatest impact for medicine. There are several restrictions on the usage of nanoparticles in X-rays. A large number of heavy atoms must be introduced in the target region without generating any harmful reactions for the purpose to improve the contrast. Stable and inert surface atoms, like those found in gold and silver, can do this. Hence, gold nanoshells have garnered significant attention, due to its low toxicity among the most promising materials for optical imaging of malignancies was recently suggested to be gold nanoshells, which are heavy metal nanoparticles (dielectric core) enclosed in gold shells (46, 47). Because gold nanoshells are non-invasive, they are safe, affordable, and have the potential to produce high-resolution imaging. The physical properties of gold nanoshells and gold colloids are comparable because both exhibit a uniform electronic response of the metal to light, leading to active optical absorption. (47).

Nanotechnology in drug delivery

As a component to therapy, drugs are often delivered to a specific target location. Whenever there is no inner route of drug delivery, exterior therapeutic modalities such as radiation therapy and surgery are used. These methods are often used separately or in combination to combat diseases. The goal of therapy is always to completely and specifically remove the tumors with the underlying illness (49). Nanotechnologies have made a major contribution to this sector by creating novel medication delivery systems. Numerous of these methods are currently within utilization and have been demonstrated to be effective in clinical settings. (50). As an instance, liposomes (Doxil®) can deliver the medicine doxorubicin, which has a high degree of toxicity, directly to tumor cells while endangering the kidneys as well as heart.

Additionally, paclitaxel alongside polymeric mPEG-PLA micelles (Genexol-PM®) is used during the chemotherapeutic treatment of metastatic breast cancers (50). Nanotechnologies have been successful in drug delivery primarily due to their improved reticuloendothelial system evasion, greater in vivo dispersion, and beneficial pharmacokinetic features. (50).

The two most important features of the perfect drug delivery system are the ability to target and regulate medicine release. Treatment efficiency is ensured and adverse effects are substantially reduced by precisely targeting and eradicating harmful as well as malignant cells. Moreover, controlled drug release may reduce side effects from medicine (51). Nanoparticle drug delivery systems offer the benefit of fewer unpleasant reactions and greater penetration into the body due to their microscopic size, which allows intravenous and other administration routes.

Nanotechnology and cancer treatment

The staggering number of people affected by cancer in the globe underscores the significance revolutionary medication delivery system which is less prone to adverse effects while being more targeted, efficient, and effective as well as an accurate technique of diagnosis (52). If a medicinal drug can reach a specific target spot without causing any adverse effects, anticancer therapies are frequently considered preferable. Chemical surface changes of nanoparticles carriers might enhance the necessary targeted delivery. Polyethylene oxide, or PEG, inclusion is one of the greatest indications of surface changes at the nanoparticle level. These changes improve the drug's capacity to target tumors as well as the specificity of absorption. Through the use of PEG, nanoparticles can travel through the circulation until they get to the tumor since the body's immune system won't recognize them as foreign items. Hydrogel's application for the treatment for breast cancer is another excellent example of this cutting-edge technology. Herceptin is a class of monoclonal antibody that targets human epidermal growth factor receptor 2 (HER2) on cancer cells in the treatment of breast cancer. Thus, a hydrogel based on vitamin E was created this, after a single dosage, may carry Herceptin to the target region for a few weeks. The hydrogel-based drug administration is more effective than traditional subcutaneous and intravenous delivery routes because Herceptin is better retained inside the tumor, which makes it a more potent anti-tumour agent (53-54). With the application of nanotechnologies, nanoparticles may be altered in a variety of methods to improve drug localization, extend circulation, boost effectiveness, and possibly even prevent the emergence of multidrug resistance.

Future prospects

This is anticipated that therapies based on nanoparticles with improved qualities including bio compatibility would be created, potentially improving the health of humans. For the purpose of accomplishing this aim, we must concentrate our investigations on making nanoparticles less harmful and on creating nanoparticles that might be able to function in a target-specific way. It is anticipated that nanotechnology will offer a platform for the creation of better treatments, perhaps revolutionizing the medical industry. The doorway to a healthy society where people have increased physical capacities will become accessible thanks to the use of nanoparticle-based medications and diagnoses.

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