

Burn skin treatment by nanoparticle – review article

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Received: 21/Dec./ 2021 , Accepted: 8 /Mar. /2022

Abstract

Background: The nanotechnology considers as one of the most promising technologies in the treatment of diseases and the manufacture of drugs with high efficiency. This review highlighted on the designing of nanoparticles (NPs) for therapeutics. The size of nanoparticle important in reaching to the target and get out from the body by kidney. Nanostructured and nanocrystalline nanomaterials are the two basic types of nanomaterials. The safe of nanoparticle is one of the most attractive attribute of nanoparticle when it will chose as a medicine. Dendrimers are extensively employed in therapeutic implementation because of their structural attribution of this component. Moreover, the capsid protein of virus is extremely natural nanoparticles can be used in medicine. Nanogels can be used for biological sensors, and other biological applications and administration of pharmaceuticals. Beside that there are many nanoparticles that have many medical applications, i.e. nanodiamonds (NDs), metallic NPs, quantum dots (QDs), Silica-Based NPs (SBNPs), Lipid-Based Nanoparticles (Liposomes).

Conclusion: One of the most important applications of NPs, which was highlighted in this review, is the use of nanoparticles in the treatment of microbial contaminated burns. Finally, it can be concluded that the using of NPs and nanomaterials with no cytotoxic effect in medication are considered one of the most important technologies that have emerged in recent years.

Key words: Antibiotic resistance, Burn, Burn infection, Nanoparticle.

Introduction

Nanoparticles are particles with a diameter of 1–1000 nanometers, which is around 1000 unit smaller than cell in the body. They're good for drug administration because, to their little stature, construction flexible, as well as a high surface-to-volume ratio. Metals, polysaccharides, and proteins are among the materials that can be used to make nanoparticles (1).

Fire exposing, electrician shock, exposing to chemical materials such as high molarity acidic materials, and exposing to high dose of radiation such as UV light, gamma radiations, and others; all result skin wounds destroying that are classified as burns.

The final goal of treatment is preventing infection and treating it while fostering a satisfactory healing process (2). Every year, about 1,000,000 people in different country suffer from moderate to severe burns. Exposing to boiling water and oil or flames because more than 88 percent of these burns (3).

The immune system's largest and most active organ of the body is the skin (4). Damage is accomplished that necessitates advanced

approaches to prevent infection burn, as well as the use. If an infection occurs, effective antimicrobial therapy is required, occurs (which almost always does) (5).

Designing Nanoparticles for Therapeutics

One of the final goals of nano-medical components is to create safer and highly effective treating nano-particles (NPs). When NPs enter the circulation system of human body will bind with protein and become the large molecules. Phagocytic system in the host body will remove the opsonized NPs from the bloodstream. Retention duration is shortened due to the immune system's fast and unspecific clearance and lowering bioavailability. The NPs surface can be coated with polyethylene glycol (PEG), polysaccharides, or/and protein molecules will show the first stage of NPs actions in human body (6).

Surface modification, on the other hand, can have an impact on the ability to recognize targeted distribution. As a result, the removability and distribution characteristics of therapeutic NPs have to be carefully studied through the stage of

drug designing. One of key element, in modulating the delivering of therapeutic NPs is their size. The filtration system through of kidney can easily remove NPs less than 10 nm, while immune engulfed cells (phagocytic cells) in the immune system that responsible for phagocytic system can clear particles larger than 200 nm.

As a result, the bloodstream spends longer time with therapeutic nanoparticles having a diameter of 100 nm.

Because therapeutic nanoparticles with a diameter of 20–200 nm are not detected by the RES and are not filtered by the kidney, many studies have revealed that they accumulate more quickly in malignancies (7-9).

In addition, compared to normal tissues, blood circulation in tumor sites are more numerous and greater in size. As a result, NPs of the right size can deliver to tumor mass quickly and staying for a high duration of time, a phenomenon identified as increased penetrability and retention (10,11).

In fact, nanoparticles are accumulated to the tumor site through passive targeting, which is accomplished without the need to functionalize nanoparticles containing a moiety for targeting. However, in active targeting, at least one sort of targeting moiety is bounded to the nanoparticle's surface of host cells such large biomolecules of and small molecules (12).

The majority of NPs are engulfed by endocytosis, which is mediated by either clathrin or caveolae. Because nanoparticles are internalized by the targeted cells, their form is also important for biodistribution. Rod-shaped cationic nanoparticles, for example, are simpler to absorb by endosomes than other cationic nanoparticle shapes, implying that immune cells recognize these nanoparticles as rod-shaped bacteria (13).

Types of Therapeutic Nanoparticles

Nanostructured and nanocrystalline nanomaterials are the two basic types of nanomaterials. The three categories of nanostructured materials are polymer in based, not polymeric materials, and NPs composed basically of lipids. Non-polymeric NPs contain carbon nanotubes and nanodiamon (13).

Liposomes and solid lipid nanoparticles are two types of lipid-based nanoparticles. Polymer-based or lipid-based nanoparticles make up the majority of clinically approved therapeutic nanoparticles

so far. Nanocrystalline particles differ from three categories of nanostructured materials in that they are created by combining medicinal ingredients in crystalline form (14).

Designing Nanoparticles for treatments

The aimed therapy is a disease therapy strategy that involves administering a therapeutic substance in appropriate amounts to the precious part of the host body for long duration. The ultimate goal of NPS used as medicine is to create safer and higher effective therapeutic NPs in order to achieve the final targets of treating the host from infection of recovering from diseases. NPs are prone to aggregation with protein molecules immediately after entering the circulation system.

Nano-Structured Particles

Polymer-Based Particles

Dendrimers

They are extensively employed in therapeutic implementation because of their structural attribution of this component. These polymer-based nanoparticles can have their number of branches regulated, allowing them to be manufactured in smallest sizes (from one to five nanometer). They're created through spherical polymerization, which causes cavities to form within the dendrimer molecule. High-generation dendrimers, such as those with higher than sixty four groups of surface, which attributed a better entrapment effectiveness than smaller dendrimers and are used to deliver medical drugs. Furthermore, dendrimers feature non-binding end groups that could easily changed and used to attachment with biocompatible chemical materials to improve the cytotoxicity and biopermeability of them. Superficial changes could be employed to increase the delivery of treating drugs to specific sites. Because they can be formed by either encapsulation or complexation, dendrimers are prospective carriers for the simultaneous transport of physiologically active substances like as vaccinations, medications, and genes to particular locations. Polyethyleneimine, polyamidoamine, poly (propyleneimine), chitin, and other mono- or copolymers are currently used in the form of dendrimers for medicinal applications (15).

Water-insoluble medicines are commonly distributed throughout the body via polymeric micelles. They have a diameter of 100 nm and agglomerate in solution. Polymeric micelles are designed of structural component molecules arranged in a spheroidal shape by a hydrophilic mantle enclosing hydrophobic core. They are protected from nonspecific uptake by having a hydrophilic surface.

Polymeric micelles, in another way, have a hydrophobic core that can actually capture water-insoluble and other therapeutic molecules. The surface engineering of nanoparticles represents a promising strategy to impart virus features onto particles, permitting changes to topology that mimic the roughness of viruses to facilitate internalization to adapting the physicochemical features to regulate changes in size and charge to mimic the infection cycle (16). The molecules can link to the non-hydrophilic core. As a result, polymeric micelles have a dynamic structure that makes them highly effective distribution vehicle for treating drugs that help in providing the high level of packing capacities and ligand conjugation (17).

Protein Nanoparticles

Virus is extremely natural transporters of their nucleic acid material that is surrounded by viral capsid proteins. Virus-like particles, a type of protein NPs, are nano-transporter systems with a shape comparable, virus body that isolated already containing the viral genetic materials, that is why the virus can be attributed as a viral genetic carriers (18,19).

Caged proteins (CP) are nanostructure protein that resemble viruses morphologically but are not derived from them. The both above proteins are interesting nano-transporter or deliverable systems for the development of tumor vaccines because they can stimulate specific immune responses against tumor mass and cells (20).

Protein NPs can also be made by self-assembling protein polymers, which are isolated proteins from animals or plants. With the benefits of polymer-based nanoparticles, protein polymers are genetically designed to self-assemble into effective drug delivery carriers. (21). Abraxane is a food and drug administration-approved protein NP medication that uses albumin to deliver paclitaxel (22).

Nano-gel

Gel is non-fluid colloidal networks that swell when they come into interaction by fluid. Nanogel is a particle having equal characteristics with a dimension of less than hundred nanometers (23). Nanogel swell because the linkage, is natural with polymers, and their flexible size and high content of water (24, 25) Physically, the cross-linking of polysaccharides of gel in which cholesterol bearing pullulans auto-aggregation into nanogel in fluid, produced the first known nanogel (through hydrophobic interactions). (26). Nanogels have various advantages over other nano-carrier systems, including less pre-mature drug leakage, potential to capture multiple treating chemicals in a single design, and simplicity of installation via drug administration ways. Nanogels can be used for biological sensors, and other biological applications. The administration of pharmaceuticals such as genetic materials, immunizations, immune-mediators, and respiratory tract vaccines are among the commonly investigated implementations of nanogel (27).

Non-Polymeric Particles

Carbon Nanotubes

Carbon nano-tube is a tubular carbon structures that has one nanometer of diameter and one to hundred nanometer length. Packaging in a monolayer of grapheme into a plane cylinder produces these structures. Single walled nanotubes, multi-walled nanotubes, and C60 fullerenes are all types of carbon nanotubes. Carbon nanotubes are useful because of their size and geometric stability (28).

Interior dimensions of SWNTs and C60 fullerenes are one to two nanometers that are about half the diameter of a conventional DNA helix. The above nanotubes can insert the cell membrane of host cells directly or through endocytosis. In the core structure of fullerenes, the arrangement of graphite cylinders and the presence of a significant number of attached double bonds differ (29).

Experiments using fullerenes have revealed that they can be utilized to deliver treatments such as antibiotics, antiviral, and anticancer drugs. (30,31).

Furthermore, being free, they can protect the wounded mitochondria. This characteristic allows for tissue-specific mitochondrial targeting, which can be exploited to deliver therapeutic medicines (32).

Nanodiamonds (NDs)

Carbon-based nanomaterials have less than 100 nm in diameter with two types of distinct facets that occur in a range of forms. Detonation, chemical vapor deposition (CVD), and high-pressure/high-temperature synthesis are among the methods used to create them (33). They have two types of unique facets and a diameter of less than 100nm. They come in a variety of shapes and sizes. Only a few of the technologies utilized to make them include detonation, chemical vapor deposition (CVD) synthesis (34).

The CVD process is preferred for depositing NDs as thin films onto diverse surfaces. The thin films made by ND are of great quality and have few flaws (35).

NDs have exclusive characteristics like superficial electrostatic characteristic, low cell toxicity due to their chemical properties, and can be immobilized various types of biological molecules, making them ideal for clinical implementations (36).

Metallic Nanoparticles

The bulk of metallic nanoparticles used in clinical implementation are made up of metals (heavy and non-heavy metals) and their oxides such as chromium dioxide, which ranged from one to hundred nanometers. They can be adorned with medicinal drugs, biomedical molecules including proteins, and nucleic acid, and can be produced and modified using a range of functional chemical groups. They have distinct characteristics as a carrier, including magnetic characteristics, constancy, and bio-composition. Magnetic NPs can be directed to a definite place in this manner. Magnetic susceptibility, or the magnetization to practical area, is a key metric for its medical uses. Super-paramagnetic iron oxide NPs are extensively utilized as dissimilarity agents for magnetic resonance picture in clinics owing to their high magnetic susceptibility (37). Super-paramagnetic characteristics, on the other hand, make it easier to transfer therapeutic chemicals to the body building cells and assure correct aggregation at the goal tissue, resulting in a repeatable and safe therapy technique (38).

Metallic NPs may make hotness when exposed to an irregular magnetic field, a process known as magnetic hyperthermia, allowing them to be used in cancer ablation (39).

Gold NPs are the type of metallic NPs, which is frequently employed, particularly in cancer specification, identification and therapy.

Quantum Dots (QDs)

They are nanocrystals or small semiconducting particles that range in size from two to ten nanometers. These particles are made up of a semiconductor inorganic core, such as CdSe, and aqueous organics coated shell, like ZnS. Different fluorescence colors exist in QDs, which is attributed in part to the particles' extremely great surface rations of volume. The QDs or structure defines the color they produce, whilst the outside aqueous shell can be used to conjugate biological molecules proteins and nucleic acid (DNA and RNA). To increase the solubility of QDs in aqueous buffers, a cap can be applied to them. Because of their limited emission, intense fluorescence, and great photostability, QDs could be used to track healing drugs into cells and or /tissues (40).

Silica-Based NPs (SBNPs)

They have significant rewards in nanotechnology because of their versatility to develop complex systems and cost issue. Their unique surface properties, permeability, and activation potential are making them appealing medicinal delivery vehicles. Silica-based nanoparticles (**SBNP**) have a large superficial area coated with groups of polar silanol, making them water-friendly and improving medicinal drug adsorption and stability. Furthermore, silica-based nanoparticles (**SBNP**) interact with DNA or RNA, allowing them to be used as aimed delivery devices.

The volume and density of their nanopore is able to adjust to maintain a rate constant delivery (41).

Lipid-Based Nanoparticles

Liposomes

They are vacuoles built by dry phospholipids membrane that have been hydrated. They can be built by assembly of lipid molecules and further surface changes to make changed structure, compose, volume, and elasticity. Liposomes'

capacity to fuse with cellular membranes and discharge their contents into the cellular-cytoplasm is one of their most significant benefits, making them ideal great transporter systems for aimed distribution. A lipid bilayer surrounds a hollow core with fifty to thousands nanometer in diameter in the noncomplex liposome. This type of core could be packed with medicinal complexes to be delivered (42).

Burn Wound Treatment and Repair using Innovative Nanoparticles

Anti-biotherapy has been beneficial in boosting human health for decades, yet it has been linked to an increase in bacterial resistance. Because it lowers drug systemic exposure, local antimicrobial therapy may be a good way to avoid bacterial resistance. A number of innovative drug delivery devices have been proposed to allow antibiotics to be administered locally. Antimicrobial light, antimicrobial agents, and ultrasound-based wound thinning are currently accessible treatment ways for burn wound healing (43).

Other choices include operating procedures, skin grafting and replacement of skin, wound coverings, pharmacological treatments, and remanufacturing and designing of tissue of skin. Degree of skin injury, as well as the type and size of nanoparticles utilized, determine their interaction with skin, as a result, of their long time in action place. The injured barrier function and irritated skin is lost, increasing the hazard of nanoparticle absorption into the circulation of host body, which can be pierced by particles

bigger than nanometers in size. Being Ecofriendly, healthy, and non-immunostimulate nanocarriers for topical drug administration to skin wounds should have the ability to release the drug in a regulated manner.

The residency period of nanoparticles in the wound, which is regulated by wound cleansing regimens, is more essential than their half-life at the place of action. Because of the mucoadhesive qualities of the nanocarrier's ground and its minor volume, the nanocarrier's residence time on the skin should also be increased.

The metabolic and biodegradation shapes, which help to lower possibility of unwanted side effects, are dependent on ground composition. The nanoparticle volume and kind must be chosen to reduce systemic absorption while still providing good treatment to the burn wounds (44).

Topical medicine administration, which primarily focuses on stimulating wound healing and preventing infection, is still an important part of wound care for all types of wounds. As a result, there is still a high demand for innovative therapeutic agents for topical wound therapy (45).

Conclusion

Burn infections are a great challenge for researchers, so it is necessary to provide alternative and efficient systems in treating burns. Therefore, researchers turned to the possibility of using nano composites of different types to treat burns, which have proven effective in treatment when used alone or when used with different antibiotics that treat b.

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معالجة حروق الجلد بواسطة المواد النانوية

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الخلاصة

خلفية عن الموضوع : يعد استخدام تقنية النانو من أكثر التقنيات الواعدة في علاج الأمراض وتصنيع الأدوية بكفاءة عالية. سلط هذه المقالة الضوء على تصميم الجسيمات النانوية المستخدمة في علاجات امراض مختلفة. إن حجم الجسيمات النانوية مهم في الوصول إلى الهدف والخروج من الجسم عن طريق الكلى. المواد النانوية ذات البنية النانوية والبلورية النانوية هما النوعان الأساسيان من المواد النانوية. تعتبر سلامة الجسيمات النانوية واحدة من أكثر سمات الجسيمات النانوية جاذبية عندما يتم اختيارها كدواء. تستخدم Dendrimers على نطاق واسع في العلاجي. علاوة على ذلك ، فإن بروتين قفيصة الفيروس عبارة عن جزيئات نانوية طبيعية للغاية يمكن استخدامها في الطب. يمكن استخدام Nanogels لأجهزة الاستشعار البيولوجية والتطبيقات البيولوجية الأخرى إضافة إلى دخوله في صناعة المستحضرات الصيدلانية. إلى جانب ذلك ، هناك العديد من الجسيمات النانوية التي لها العديد من التطبيقات الطبية ، مثل الماس النانوي (NDs) ، NPs المعدنية ، النقاط الكمومية (QDs) ، NPs القائمة على السيليكا (SBNPs) ، الجسيمات النانوية الدهنية (الجسيمات الشحمية).

الاستنتاج: أحد أهم تطبيقات NPs ، والتي تم تسليط الضوء عليها في هذه المراجعة ، هو استخدام الجسيمات النانوية في علاج الحروق الجرثومية الملوثة. أخيرًا ، يمكن الاستنتاج أن استخدام NPs والمواد النانوية التي ليس لها تأثير سام للخلايا في الأدوية تعتبر من أهم التقنيات التي ظهرت في السنوات الأخيرة.

الكلمات المفتاحية :- مقاومة المضادات ، الجلد ، إصابات الجلد ، المواد النانوية .