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Nanotechnology Based Medications of Photo Dynamic Therapy for Cancer Diseases

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Abstract

Deregulation of cell growth and development lead to cancer, a severe condition that claims millions of lives worldwide. Targeted or selective approaches used during cancer treatment determine the efficacy and outcome of the therapy. Photo dynamic therapy (PDT) is a favourable option attitude for enhanced cancer disease treatment. In PDT, a photosensitizer (PS) is regulated that and enacted by the light of a particular wavelength, that causes specific harm to the tumour. The achievement of PDT is constrained by the trouble in controlling photosensitizers with low water solubility. Nanotechnology in medicine uses tiny particles (10^9 meters in length) to help deliver drugs to places that need them. Nanotechnology based medication conveyance frameworks may enhance the transcytosis of a PS across over epithelial and endothelial obstructions and manage the synchronous co-conveyance of at least two medications. One profound use for nanotechnology has been the treatment of cancer, a notoriously difficult cancer to treat using traditional chemotherapy. One of the most fascinating uses for nanotechnology is the various kinds of drug delivery that can be done using it. So, the utilization of nanotechnology in medication may offer various energizing conceivable outcomes in tumour treatment and enhance the viability of accessible therapeuticsnt. This paper summarizes the development of nanoparticles for efficient photodynamic therapy for cancer diseases.

Keywords

Cancer Diseases, Medications, Nanotechnology, Photo Dynamic Therapy

1. Introduction

Nanotechnology achieved significant scientific and technological advances in the fields of medicine and physiology. Nanotechnology based medications for photo-dynamic therapy of cancer provide a more efficient way to overcome the problems. Nanotechnology by definition involves dealing with particles that are very small (nanosized - about 10^9 meters in length). There is a myriad of different types of nanomaterial's used as drug delivery agents, such as, nanoparticles, dendrimers, ceramic nanoparticles, chitosan nanoparticles, liposomes, low-density lipoproteins, Nano emulsions, and nanospheres. Each of these has its own benefits and flaws, and thus researchers must decide which of them is ideal for the treatment that is needed in a given case. Molecules, such as nanoparticles, that approach the atomic level often have different properties than their macromolecular counterparts. According to the "Nanotechnology and Nanotoxicology" article, "gold is an inert metal; Nanoparticles of gold less than 10 nm in diameter burst into flames on contact with oxygen". Clearly there are many dangers associated with using nanotechnology. Engineers have an implicit ethical responsibility not to let foreseeable harm come to clients, or, in this case, patients. This means that before proceeding to clinical trials, the various nanotechnologies must be tested to be as safe as possible for patients due to the various hazards involved with working with such new and potentially deadly technologies. There are, however, many boons that come with these innovations as well. Present day chemotherapy using powerful drugs is the standard of care for different

cancers. However, this kind of therapy is often nonspecific and thus can cause a wide range of side effects as the drugs kill healthy cells as well malignant ones; what nanotechnology allows medical professionals to achieve is a much more precise way to eliminate cancer cells without harming healthy ones. It is clear, therefore, that advancements in nanotechnology serve to better the healthcare and the treatments of individuals throughout the world. Moreover, PDT is viewed as a promising option treatment methodology to current medicines against a few sorts of tumours. A non-lethal dye is directed to the patients with consequent coverage to a light source of wavelength that prompts to the death of the objective cell through oxidative harm. Three segments act at the same time in PDT: a photosensitizer (PS), a light source, and oxygen. The PS and light source must be innocuous to the objective cell [1-2]. At the point when the PS is energized by light of a particular wavelength, its connections with the environment can take after two pathways. These pathways are named Sort I and Sort II reactions, as delineated in Figure 1. In sort I reactions, the PS in its energized triplet state responds with biomolecules, exchanging hydrogen atoms by means of the radical component. It creates free radicals and radical particles that then respond with oxygen resulting in receptive oxygen species (ROS) generation.

The paper is adorned in this fashion; nanotechnology-based medication is explained elaborately with nanoparticle systems, liposomes, hydrogels, liquid crystalline systems, and dendrimers in section 2, and challenges and recovery systems in cancer diseases medication are described in section 3, which is concluded the paper.

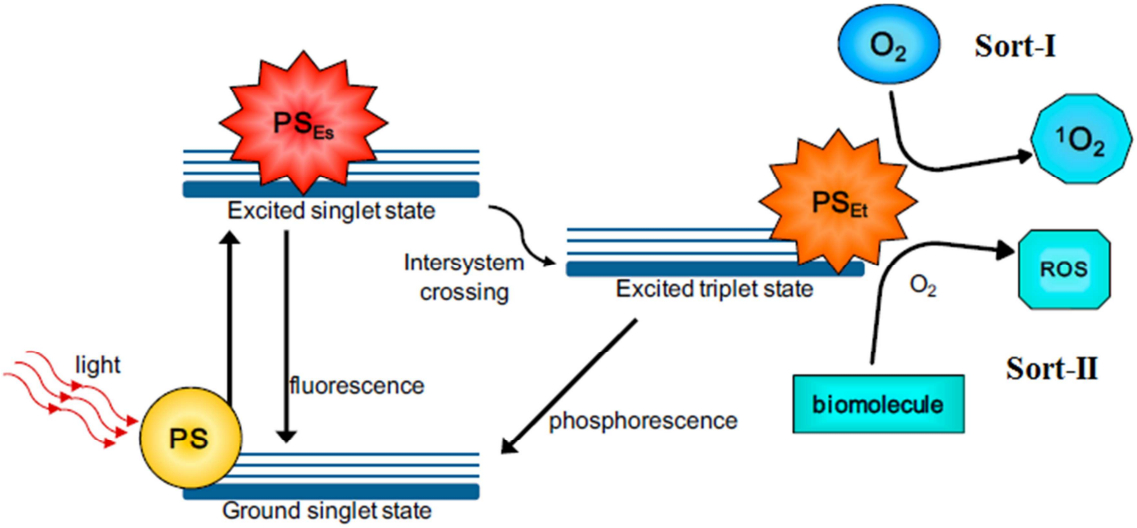
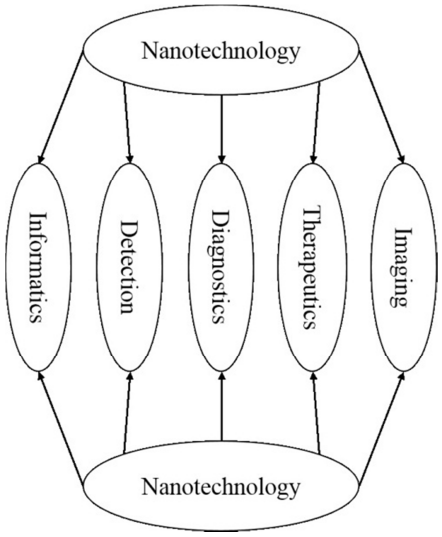
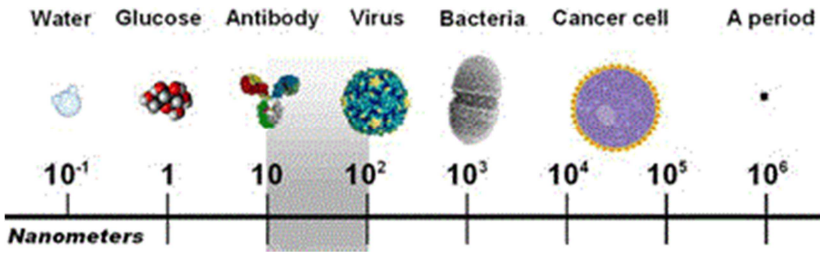


Figure 1. *Sort-I and Sort-II reactions in photodynamic therapy.*

Sort II responses depend on a wonder called triplet–triplet annihilation. In these responses, the PS in its energized triplet state responds with the oxygen in its triplet ground state. This yields singlet oxygen that is extremely responsive and cytotoxic. Both sorts of responses occur in the same time [3].



(a)



(b)

Figure 2. *(a) Nanotechnology applications and (b) Nanoscale materials.*

Table 1. *Benefits and drawbacks of Photodynamic Therapy (PDT).*

Benefits	Drawbacks
-Less antagonistic impacts.	-Photosensitivity after treatment.
-Can be applied at a similar area several times.	-Treatment adequacy relies on exact light conveyance to the tumor.
-Short treatment time.	-Tissue oxygenation is critical to the photodynamic impact.
-Lower costs than various medications.	-Difficult to treat metastatic diseases with this innovation.

However, nanotechnology-based PS conveyance signify a rising way to deal with enhance the result of cancer PDT. Improvement of the nanotechnology-based medication conveyance frameworks, for example, outlined in the Figure 2, can encourage exact PS intracellular conveyance. Moreover, nanotechnology-based medication conveyance frameworks have advantages, for example, (1) enhanced conveyance of ineffective water-soluble PS, (2) encouraging transcytosis of PS crosswise over tight epithelial and endothelial boundaries, (3) conveyance of substantial macromolecular PS to intracellular locales of activity and (4) co-conveyance of at least two medications for mix treatment [4]. The accompanying section shows the endeavours of analysts to make novel procedures to create nanotechnology-based medication conveyance frameworks in cancer PDT.

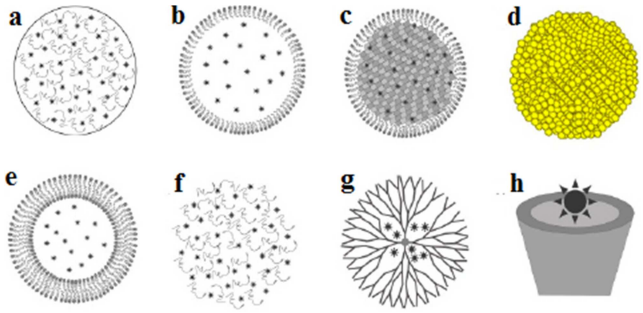


Figure 3. *Nanotechnology constructed medications like, (a) PNPs, (b) NLCs, (c) SLNs, (d) AuNPs, (e) liposomes, (f) hydrogels, (g) dendrimers, and (h) cyclodextrin.*

2. Nanotechnology Based Medications

2.1. Nanoparticle Systems

Nanoparticles (NPs) are sub-micrometre measure particles. They have various points of interest as a PS conveyance framework, for example, (i) assurance of the PS against enzymatic degradation, (ii) the control of PS discharge permitting a steady and uniform focus into target cells, (iii) the capacity to enter target cells, (iv) biocompatibility as well as restorability through common pathway, and (v) photo stability. Now, the PNPs are set up from natural or manufactured polymers, for example, PLGA, PLA, PCL and gelatin [5]. In the mid-1990s, SLNs produced using solid lipids and particles were acquainted as an option to the PNP. SLNs don't present the drawbacks that some PNPs present, for example, cytotoxicity [6]. However, the SLNs additionally have a few restrictions, for example, low epitome effectiveness, sedate removal amid capacity, and crystallization. Thusly, NLCs were created to conquer these difficulties. NLCs are framed by solid lipid and fluid lipid stages, which makes a scattered network [7]. Another kind of NP that exceeded expectations incredibly as a medication conveyance framework is the metallic nanoparticles (MNs). MNs are NPs functionalized basically by gold (AuNPs). Because of monolayer tenability, the AuNPs can be stacked with the medication by various instruments. Besides, it is tranquil to control the objective, dependability, and arrival of the medication from AuNPs.

2.2. Liposomes

A commonly used nanomaterial for drug transport is the liposome. A liposome is made up of a phospholipid membrane that has an inner core where drugs can be placed, and these liposomes can be molded into various shapes and sizes that suit any particular purpose. These can be very useful because some drugs have poor solubility otherwise, and the use of the liposomes allows them to be several times more affective. Liposomes are just one example of nanotechnology being used for drug delivery. While typically drug delivery involves intravenous injection of nanomaterial's containing the drug, one method is becoming more and more prominent: drug delivery through inhalation of nanomaterials. Clinically, liposomes are the most settled controlled medication conveyance framework because of their auxiliary adaptability and their capacity to fuse an assortment of hydrophilic and hydrophobic medications. Subsequently, liposomes can be utilized to consolidate

lipophilic and hydrophilic PSs utilized in cancer PDT [8]. Micro-particles are the next step beyond liposomes; they are naturally occurring or synthetic polymers that are more stable chemically than liposomes. Therefore, they can survive in a much tougher and more likely to survive in the body's extreme environment. However, they also serve a similar role to liposomes: encapsulating drugs that can be delivered to specific cells. Many of these nanoparticles have specific receptors so that they attach themselves to specific cancer cells, without harming other cells.

2.3. Hydrogels

Hydrogels frameworks are broadly utilized for the controlled settlement of hydrophilic medications, predominantly because of the simplicity of scattering the medication in the matrix. Furthermore, they are biocompatible and have physical properties that are comparative with living tissues [9].

2.4. Liquid Crystalline Systems

Lyotropic liquid precious crystal system have characteristics of both fluids (since they are liquids) and solids. They are shaped by surfactants, more absolutely by them solvates or hydrates, such as lamellar, hexagonal, etc. The lamellar fluid crystals display low interfacial strains with oil regardless of their negligible oil solubilisation and they have low viscosities. The cubic mesosphere introduces additionally confounded structures to be visualised, typically showing a cubic symmetry. Furthermore, the tetragonal and rhombohedra stages were likewise recognized in a few frameworks [10].

2.5. Dendrimers

Dendrimers are highly branched polymers and gives more prominent sureness in foreseeing the measure of consolidated medication. Moreover, it empowers reproducible pharmacokinetics, which makes dendrimers a fascinating medication conveyance framework for PDT. There are three approaches to conjugate PS in dendrimers: (i) PS is caught in the voids of a dendrimer; (ii) PS is covalently bound, and (iii) PS is utilized as a framework to shape a dendrimer [11].

3. Challenges and Recovery

There are numerous ethical dilemmas when it comes to nanotechnology and nanotechnology manufacture. As mentioned earlier, one of the risks associated with new technology is the toxicity that the Nanodrugs may have on otherwise healthy cells. In addition to the nanoparticles' toxicity on cells, one must also worry about other toxic effects from the technology. The challenge in oncology is specifically crushing the tumour cells without hurting healthy cells. In such manner, PDT offers clear favourable circumstances over other therapeutic modalities, for example, chemotherapy and radiotherapy. It requires a corresponding nearness of PS and light for the photodynamic impact to occur. Along these lines, the photodynamic activity can be specially limited in dangerous tissues bringing about irreversible decimation of tumour cells. Besides, there is a noteworthy trouble in setting up a proper interim between PS organization and light illumination, which is crucial for the success of PDT. Moreover, if the light illumination is too soon, it will just affect the tumour vasculature. However, if the light illumination is too late, it will have a decreased effect because of PS clearance [12]. Hence, these difficulties persuade researchers to enhance PDT utilizing nanotechnology-based medication frameworks.

4. Conclusion

Finally, Photodynamic therapy (PDT) is a minimally invasive therapeutic modality used in the management of various cancerous and pre-malignant diseases. Many conventional antitumor treatments carry the risk of inducing immunosuppression, which is not associated with the use of PDT. Detailed studies on the molecular mechanisms of cytotoxicity are necessary to better understand therapeutic outcomes that could be translated into more effective therapeutic regimens

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References

[1] M. Fink, H. Ermert, S. Lyer and C. Alexiou, "Sonographic detection of magnetic nanoparticles for Magnetic Drug Targeting using coded magnetic fields", IEEE International Conferences on Ultrasonics Symposium, 2016, Doi: 10.1109/ULTSYM.2016.7728404.

[2] J. L. Fleck and C. G. Cassandras, "Personalized cancer therapy design: Robustness vs. optimality", IEEE Conference on Decision and Control (CDC), 2016, Doi: 10.1109/CDC.2016.7799040.

[3] G. Giordano, A. Rantzer and V. D. Jonsson, "A convex optimization approach to cancer treatment to address tumor heterogeneity and imperfect drug penetration in physiological compartments", IEEE Conference on Decision and Control (CDC), 2016, Doi: 10.1109/CDC.2016.7798636.

[4] B. Yu, "Quantitative optical spectroscopy and imaging for cancer diagnosis and treatment monitoring", Electromagnetic Research Symposium, 2016, Doi: 10.1109/PIERS.2016.7734946.

[5] A. Babu, R. Muralidharan and N. Amreddy, "Nanoparticles for siRNA-based gene silencing in tumor therapy", IEEE Transactions on NanoBioscience, 2016, Doi: 10.1109/TNB.2016.2621730.

[6] M. M. Hasan and M. F. Hossain, "Facial features detection in color images based on skin color segmentation", IEEE International Conference on Informatics, Electronics & Vision (ICIEV), 2014, pp.1-5, Doi: 10.1109/ICIEV.2014.6850763.

[7] F. H. Shashi, I. Misbah and S. A. Muyeed, "Absorption properties of Silver-Silica-Gold Nanomatryushka particle and its optimization for photo-thermal cancer therapy", IEEE International Conference on Informatics, Electronics and Vision (ICIEV), 2016, Doi: 10.1109/ICIEV.2016.7760099.

[8] J. Guo, G. Chen, J. Wu and C. T. Chin, "Passive delivery of liposomes to mouse brain after blood-brain barrier opening induced by focused ultrasound with microbubbles", IEEE International Ultrasonics Symposium (IUS), 2015, Doi: 10.1109/ULTSYM.2015.0405.

[9] T. Dumitriu, R. P. Dumitriu and V. Manta, "Application of Artificial Neural Networks for modeling drug release from a bicomponent hydrogel system", International Conference on System Theory, Control and Computing (ICSTCC), 2016, Doi: 10.1109/ICSTCC.2016.7790744.

[10] R. Chuealee, P. Aramwit and T. Srichana, "Characteristics of Cholesteryl Cetyl Carbonate Liquid Crystals as Drug Delivery Systems", IEEE International Conference on Nano/Micro Engineered and Molecular Systems, 2007, Doi: 10.1109/NEMS.2007.352210.

[11] A. M. Caminade, C. O. Turrin and J. P. Majoral, "Biological properties of water-soluble phosphorhydrazone dendrimers", Braz. J. Pharm. Sci., 2013, 49, 33–44.

[12] N. Challapalli, M. E. Ahsen and M. Vidyasagar, "Modelling drug response and resistance in cancer: Opportunities and challenges", IEEE Conference on Decision and Control (CDC), 2016, Doi: 10.1109/CDC.2016.7798635.