Current Trends in Biomedical Engineering & Biosciences
ISSN: 2572-1151

Juniper Publishers
key to the Researchers

Mini Review
Volume 11 Issue 3 - January 2018
DOI: 10.19080/CTBEB.2018.11.555815

Curr Trends Biomedical Eng & Biosci

Nanoparticles: Smart Drug Delivery Systems

Yogita Patil-Sen*

School of Physical Sciences and Computing, University of Central Lancashire, UK

Submission: December 15, 2018; **Published:** January 24, 2018

***Corresponding author:** Yogita Patil-Sen, School of Physical Sciences and Computing, University of Central Lancashire, Preston, PR1 2HE, UK, Email: ypatil-sen@uclan.ac.uk

Abstract

Nanoscale drug delivery systems using nanoparticles are emanating technologies for targeted and localized delivery of the therapeutic drug. The use of nanoparticles offers several advantages including enhanced pharmacokinetic drug profile, controlled and sustained release of drug and reduced toxicity. This opinion article briefs the important classes of the nanoparticles as drug carrier systems.

Keywords: Nanotechnology; Nanoparticles; Drug delivery; Therapeutics

Introduction

Nanotechnology is a promising scientific approach to manufacture, engineer and fabricate materials, such as nanoparticles whose size ranges between 1-1000nm scale [1]. Their extremely small size, large surface area to volume ratio and potential to functionalize their surface provide nanoparticles excellent physico-chemical properties for their various applications [2]. The potential uses and benefits of nanotechnology are enormous. Over the last few decades, nanotechnology has gathered a lot of attention in the field medicine, pharmaceutical science, materials science and food technology [3]. Nanoparticles have been extensively explored for diagnostic and therapeutic applications in medical and pharmaceutical industry to cure diseases such as cancer.

Nanoparticles loaded with the therapeutic drug can be transported to disease site for targeted drug delivery using active, passive or physical targeting method. Active targeting involves modifying the nanoparticle surface by binding ligands such as antibodies and proteins onto the surface of nanoparticle in order to increase their uptake by target site [4]. Small size, morphology and electrochemical properties of nanoparticles influence the enhanced permeation retention effect, thus increasing the ability of tumor cells to absorb the nanoparticles compared to the normal cells. Hence the nanoparticles can be passively targeted to the site [5,6]. Physical targeting uses external stimuli to guide the nanoparticle to the target site [7]. The external stimuli also control the drug release process. For example, in case of photothermal therapy light is used whereas in magnetic hyperthermia therapy, magnetic field is used to guide the nanoparticles to the target site.

Types of Nanoparticles

Liposomes

Lipids are integral part of all living things and exist in nature as bi-layered nanostructure [8]. Liposomes are lipid based nanostructures which are mimics of these naturally occurring bi-layered structures. Liposomes provide biocompatible nanoparticles and have been extensively studied over the years for drug delivery applications [3,9,10]. Doxil and DaunoXome are some of the liposome formulations that have been approved by the Food and Drug Administration (FDA) for cancer therapy [11-13].

Polymeric nanoparticles

Due to their biocompatibility and biodegradability, polymeric nanoparticles are particularly promising in the field of drug delivery. The polymeric matrices that are widely explored are poly (glycolic acid) (PGA), poly (lactic-co-glycolic acid) (PLGA), poly (lactic acid) (PLA) and poly(caprolactone) (PCL) [14-16]. Some of the polymeric nanoparticle formulations are either FDA approved or currently in clinical trials [17-19].

Metallic nanoparticles

Gold, Silver and Iron oxide nanoparticles, especially magnetite (Fe_3O_4), are the most studied metal-based nanoparticles in biomedical field [20,21]. Ferumoxide has been FDA approved Magnetic Resonance Imaging contrast agent and iron oxide has also been EU approved for cancer therapy.

Other types of nanoparticles

In addition to liposomes, polymeric and metallic nanoparticles, carbon nanotubes [3,9], titanium nanotubes [22], peptide based nanoparticles [20] and quantum dots [23,24] have also been researched in this regard. More recently, cell membrane coated nanoparticles are emerging as biomimetic strategy wherein a nanoparticle core is camouflaged with cell membrane derived from natural cell such as erythrocyte or white blood cell or cancer cell. These bio-inspired cell membrane coated nanoparticles have shown strong potential not only in drug delivery but also in immune modulation, vaccination and detoxification [25].

Nanoparticles in Drug Delivery: Challenges

Even with the tremendous benefits of nanoparticles in drug delivery, very few have made the 'bench to market' translation. The reasons behind this are: several of these particulate systems suffer from lack of structural integrity, instability during storage and most often these are quite toxic to the cells of the body. The physico-chemical properties such as size and surface charge play important roles in determining stability and toxicity of the nanoparticles. Thus, these challenges must be overcome in order to enhance the properties of the nanoparticles and improve their suitability in drug delivery applications.

Conclusion

Over the years, nanoparticles have proven to provide an excellent drug carrier system for smart and targeted delivery. By clever engineering it has been possible to manufacture and fabricate various types of nanoparticles, each with its own advantages and suitability for nanotechnology applications. Nanoparticles, thus, hold tremendous promise to revolutionize nanomedicine and to provide treatment for a myriad of important human diseases such as cancer.

Acknowledgement

Author Y Patil-Sen gratefully acknowledges the Daphne Jackson Trust for the fellowship which is jointly sponsored by the Royal Society of Chemistry and University of Central Lancashire, UK.

Conflict of Interest

The author declares that there is no economic interest and no conflict of interest regarding the publication of this article.

References

1. Fang RH, Jiang Y, Fang JC, Zhang L (2017) Cell membrane-derived nanomaterials for biomedical applications. Biomaterials 128: 69-83.
2. Rubul Mou, Daniel Moyano F, Subinoy R, Vincent M (2012) Surface functionalization of nanoparticles for nanomedicine. Chemical Society Reviews 41(7): 2539-2544.
3. Patil-Sen Y, Sadeghpour A, Rappolt M, Kulkarni CV (2016) Facile Preparation of Internally Self-assembled Lipid Particles Stabilized by Carbon Nanotubes. Jove-Journal of Visualized Experiments (108): 53489.
4. Bertrand N, Wu J, Xu X, Kamaly N, Farokhzad OC (2014) Cancer nanotechnology: The impact of passive and active targeting in the era of modern cancer biology. Advanced Drug Delivery Reviews 66: 2-25.
5. Matsumura Y, Maeda H (1986) A New Concept for Macromolecular Therapeutics in Cancer Chemotherapy: Mechanism of Tumoritropic Accumulation of Proteins and the Antitumor Agent Smancs. Cancer Research 46 (12 Part 1): 6387-6392.
6. Maeda H (2001) Mechanism of tumor-targeted delivery of macromolecular drugs, including the EPR effect in solid tumor and clinical overview of the prototype polymeric drug SMANCS. Journal of Controlled Release 74(1): 47-61.
7. Huang X (2007) Plasmonic photothermal therapy (PPTT) using gold nanoparticles. Lasers in Medical Science 23(3): 217.
8. Patil-Sen Y (2004) A monolayer phase behaviour study of phosphatidylinositol, phosphatidylinositol 4-monophosphate and their binary mixtures with distearoylphosphatidylethanolamine. Physical Chemistry Chemical Physics 6(7): 1562-1565.
9. Gaunt NP (2015) Carbon nanotubes for stabilization of nanostructured lipid particles. Nanoscale 7(3): 1090-1095.
10. Kulkarni CV (2015) Lipid-hydrogel films for sustained drug release. International Journal of Pharmaceutics 479 (2): 416-421.
11. Hofheinz RD (2005) Liposomal encapsulated anti-cancer drugs. Anti-cancer drugs 16(7): 691-707.
12. Immordino ML, Dosio F, Cattel L. (2006) Stealth liposomes: review of the basic science, rationale, and clinical applications, existing and potential. International journal of nanomedicine 1(3): 297-315.
13. Barenholz YC (2012) Doxil®-the first FDA-approved nano-drug: lessons learned. Journal of controlled release 160(2): 117-134.
14. Patel T (2012) Polymeric nanoparticles for drug delivery to the central nervous system. Advanced Drug Delivery Reviews 64(7): 701-705.
15. Dash TK and Konkimalla VB (2012) Poly-ϵ-caprolactone based formulations for drug delivery and tissue engineering: A review. Journal of Controlled Release 158(1): 15-33.
16. Kumari A (2010) Biodegradable polymeric nanoparticles based drug delivery systems. Colloids and Surfaces B: Biointerfaces 75(1): 1-18.
17. Fox ME (2009) Soluble Polymer Carriers for the Treatment of Cancer: The Importance of Molecular Architecture. Acc Chem Res 42(8): 1141-1151.
18. Dinndorf PA (2007) FDA drug approval summary: pegaspargase (oncaspar) for the first-line treatment of children with acute lymphoblastic leukemia (ALL). Oncologist 12(8): 991-998.
19. Oerlemans C (2010) Polymeric Micelles in Anticancer Therapy: Targeting, Imaging and Triggered Release. Pharmaceutical Research 27(12): 2569-2589.
20. Majid A (2017) Tunable Self-Assembled Peptide Structure: A Novel Approach to Design Dual-Use Biological Agents. Materials Today: Proceedings 4(1): 32-40.
21. Patil-Sen Y, Chhabria V. Superparamagnetic Iron Oxide Nanoparticles for Magnetic Hyperthermia Applications, Francis and Taylor.
22. Kulkarni M (2015) Wettability studies of topologically distinct titanium surfaces. Colloids and Surfaces B-Biointerfaces 129: 47-53.
23. Ekimov A, Onushchenko A (1981) Quantum size effect in three-dimensional microscopic semiconductor crystals. ZhETF Pisma Redaktsiiu 34: 363-366.
24. Resch-Genger U (2008) Quantum dots versus organic dyes as fluorescent labels. Nature methods 5 (9): 763-775.
25. Narain A(2017) Cell membrane coated nanoparticles: next-generation therapeutics. Nanomedicine 12(21): 2677-2692.

How to cite this article: Yogita P. Nanoparticles: Smart Drug Delivery Systems. Curr Trends Biomedical Eng & Biosci. 2018; 11(3): 555815. DOI: 10.19080/CTBEB.2018.11.555815.

DOI: 10.19080/CTBEB.2018.11.555815

How to cite this article: Yogita P. Nanoparticles: Smart Drug Delivery Systems. Curr Trends Biomedical Eng & Biosci. 2018; 11(3): 555815. DOI: 10.19080/CTBEB.2018.11.555815.