Austin Journal of Nanomedicine & Nanotechnology

Open Access

Austin Publishing Group

Editorial

Nanoformulations as Drug Delivery Vehicles for Cancer Treatment

Punuri Jayasekhar babu[1]*, Sibyala Saranya[2] and Venkataswamy Mallepogu[2]

[1]Biomaterials Laboratory, Department of Materials Engineering, Indian Institute of Science (IISc), India

[2]Department of Biochemistry, Sri Venkateswara University, India

***Corresponding author:** Dr Punuri Jayasekhar Babu, Department of Materials Engineering, Indian Institute of Science, India, Email: jayasekhar.punuri@gmail.com

Received: November 05, 2014; **Accepted:** January 20, 2015; **Published:** February 14, 2015

Editorial

Cancer is a class of diseases characterized unregulated cell growth, medically known as a malignant neoplasm and is an important worldwide public health concern. There are over 100 different types of cancer, and each is classified by the type of cell that is initially affected. Many ways of treating the cancer includes the chemotherapy, radiation, hormonal therapy, immunotherapy, transplantation and targeted therapy. Chemotherapy plays a major important role curing the all most all types of cancer. However, the major problem with chemotherapy for the treatment of cancer is the lack of selective toxicity, results in the damage of normal healthy cells which will narrow down therapeutic index, and thereby compromises clinical prognosis. In order to minimize damage to normal tissues, sub-optimal doses of anticancer chemotherapeutics are often administered which again results in improper treatment of cancer.

The problems associated in treating the cancer are poor bio distribution and high penetration of drug in to normal cells due to high interstitial fluid pressure (IFP) [1, 2]. It reported that the amount of drug accumulated in normal viscera is 10 to 20-fold higher than that in the same weight of tumor site [3, 4], and many anticancer drugs are not able to penetrate more than 40–50 mm (equivalent to the combined diameter of 3–5 cells) from the vasculature [5, 6]. These defects often lead to incomplete tumor response, multiple drug resistance, and ultimately therapeutic failure [7]. To address and cater the demand of the novel therapeutic methods; nanotechnology emerged as a solution for the treatment of cancer. Nanotechnology has opened a window for the development of diverse organic and inorganic drug carriers known as nanoparticles. Nanotechnology holds significant promise for circumventing these challenges by enabling large amounts of therapeutic drugs to be encapsulated into nanoparticles. This simultaneously increases the half-life and reduces toxic adverse effects of drugs, improving their pharmacokinetic profile and therapeutic efficacy [8-10]. Some of the source materials that can be used to prepare the nanomaterials include phospholipids, lactic acid, chitosan, dextran, polyethylene glycol (PEG), cholesterol, carbon, silica, and some metals [11-15]. The surface of nanoparticles is further modified by covalent conjugation with small functional groups that increase their targeting potential. Functional groups that improve the nanoparticles specificity include folate, antibodies, aptamers, and the tripeptide Arg-Gly-Asp (RGD) [16]. The use of nanotechnology in cancer treatment offers some exciting possibilities, including the possibility of destroying cancer tumors with minimal damage to healthy tissue and organs, as well as the detection and elimination of cancer cells before they form tumors. In this section, we discussed the major nanoparticle platforms used as drug delivery systems for the treating the cancer.

Polymer based nanoparticles: are colloidal solid particles prepared from biodegradable polymers such as chitosan, gelatin and collagen poly caprolactone (PCL) or non-biodegradable polymers such as poly(lactic acid) (PLA) and poly (lacticco-glycolic acid) (PLGA) [17-19]. The advantages of these molecules being using as drug delivery systems includes specificity to target site, penetrability of capillaries, changing the physio-chemical and pharmacokinetics properties which helps in accumulation high dosage of drug at targeted site [14, 20]. For example, paclitaxel-loaded PEG-PLGA-based nanoparticles grafted with RGD peptide. In this study Danhier *et al.* found that the target nanoparticles reduced tumor growth more efficiently, and prolonged survival time of mice compared with non-targeted nanoparticles [13].

Polymer derived Micelles: Micelles of less than 100 nm assembled with a hydrophobic core and hydrophilic shell are commonly used as drug carriers [14, 20] and are prepared by using poly (ethylene oxide)-poly(-benzyl-L-aspartate) and poly (*N*-isopropylacrylamide)-polystyrene. Their hydrophobic core and hydrophilic shell make micelles potent nanocarriers for poorly water soluble anticancer drugs, including paclitaxel and docetaxel [21, 22]. For example, (cRGD)-PEG-polyplex micelles, in this study they found that cRGD-PEG-polyplex micelles achieved significantly more efficient gene expression and cellular uptake compared with ligand-free PEG-micelles in i*n-vitro* [23].

Metallic nanoparticles: include gold, nickel, silver, iron oxide, zinc oxide, gadolinium, and titanium dioxide particles [17,24-26]. The major advantage of using metallic nano particles is, providing the large surface area which enables the incorporation of high drug doses For example, Qian *et al.* reported the use of biocompatible PEG coated gold nanoparticle for tumor targeting which was detected by surface-enhanced Raman scattering (SERS) [27].

Liposome based nanoparticles; are range in 30-100 nm formed by self-organization of phospholipids such as phosphatidylcholine, phosphatidylethanolamine, phosphatidylglycerol and phosphatidylserine, and other molecules such as cholesterol. These are most widely used as delivery systems for small molecules, peptides, small and long nucleic acids, and proteins. For example, Vyas et.al demonstrated the delivery of the amphotericin B in to the alveoloar macrophages to treat the fungal infections [28].

Citation: babu PJ, Saranya S and Mallepogu V. Nanoformulations as Drug Delivery Vehicles for Cancer Treatment. Austin J Nanomed Nanotechnol. 2015;3(1): 1038.

Dendrimers; are synthetic polymers made of macromolecules such as poly (*N*-isopropylacrylamide)-polystyrene and poly(ethylene oxide)-poly(-benzyl-L-aspartate) with an inner core diameter of less than 15 nm, repetitive units of several interior layers and multiple peripheral functional groups. They can be manipulated in terms of their size, shape and dimensions as their synthesis involves assembling of monomer in stepwise manner. For example, Barker et al. produced dendrimers conjugated with fluorescein (FITC) and folic acid (FA) for imaging and therapeutic purposes [29]. In this study, dendrimers were linked with complementary DNA oligonucleotides to produce clustered molecules that target the cancer cells over which are expressing folate receptors [29].

Quantum dots; are nanoctystalline materials composed of the 10-15 atoms from II-IV or and III. The size and shape of quantum can be controlled precisely and that determines their absorption and light emission. For example, fluorescent QD are stable, highly sensitive and multi contrast imaging agents for detection and diagnosis of cancer *in vivo*.

Fullerenes; are a family of structures composed entirely of carbon and can be classified in to two categories based on their structure: single-walled carbon nanotubes (SWNT) (one graphite sheet) or multi-walled carbon nanotubes (MWNT) (several concentric graphite sheets) and possess unique properties includes electronic, structural, and thermal characteristics that made them appropriate vehicles for drug delivery systems. The main drawback of fullerenes are insoluble in several solvents, provoking toxicity problems, However, we can modify the surface area and can be used for the as biosensors for detecting protein, DNA, diagnostics, and carriers. For example, Liu *et al*. used single-walled carbon nanotubes (SWNT) chemically functionalized with PEG-paclitaxel (SWNT-PEG-PTX) in a xenograft breast cancer mouse model [30].

Polymer based nanofibers: are inorganic (*i.e.*, titanium, silicon or aluminum oxides) or organic (polyvinyl alcohol, gelatin, poly (*N*-isopropylacrylamide, polycaprolactone, or polyurethane) materials consist of large surface area, high pore volume and tight pore size. Nanofibers have been used extensively as drug delivery systems. For example, Tseng et al. used biodegradable nanofibers to successfully deliver vancomicyn, an antibiotic, to the brain tissue of rats and reduce the toxicity associated with parenteral antibiotic treatment [31]. These can be applied in several fields such as medical (tissue engineering), filtration, barriers, wipes, personal care, composite, insulation, garments, and energy storage.

Nanoparticle formulations as anticancer drug delivery systems have greatly improved the therapeutic efficacy and clinical prognosis. Liposome are widely used as drug carriers for cancer treatment over other formulations as they possess special properties such as biocompatibility, biodegradability, low cost, stability, long circulating times and high encapsulation efficiency. However, current nano formulations have their own limitation as drug carriers for treating the cancer and should be addressed without a doubt.

References

1. Heldin CH, Rubin K, Pietras K, Ostman A. High interstitial fluid pressure - an obstacle in cancer therapy. Nat Rev Cancer. 2004; 4: 806-813.
2. Provenzano PP, Cuevas C, Chang AE, Goel VK, Von Hoff DD, Hingorani SR. Enzymatic targeting of the stroma ablates physical barriers to treatment of pancreatic ductal adenocarcinoma. Cancer Cell. 2012; 21: 418-429.
3. Bosslet K, Straub R, Blumrich M, Czech J, Gerken M, Sperker B, et al. Elucidation of the mechanism enabling tumor selective prodrug monotherapy. Cancer Res. 1998; 58: 1195-1201.
4. Chang DK, Lin CT, Wu CH, Wu HC. A novel peptide enhances therapeutic efficacy of liposomal anti-cancer drugs in mice models of human lung cancer. PLoS One. 2009; 4: 4171.
5. Hambley TW, Hait WN. Is anticancer drug development heading in the right direction? Cancer Res. 2009; 69: 1259-1262.
6. Minchinton AI, Tannock IF. Drug penetration in solid tumours. Nat Rev Cancer. 2006; 6: 583-592.
7. Szakács G, Paterson JK, Ludwig JA, Booth-Genthe C, Gottesman MM. Targeting multidrug resistance in cancer. Nat Rev Drug Discov. 2006; 5: 219-234.
8. Davis ME1, Chen ZG, Shin DM . Nanoparticle therapeutics: an emerging treatment modality for cancer. Nat Rev Drug Discov. 2008; 7: 771-782.
9. Farokhzad OC, Langer R. Impact of nanotechnology on drug delivery. ACS Nano. 2009; 3: 16-20.
10. Shi J, Votruba AR, Farokhzad OC, Langer R. Nanotechnology in drug delivery and tissue engineering: from discovery to applications. Nano Lett. 2010; 10: 3223-3230.
11. Bangham AD, Standish MM, Watkins JC. Diffusion of univalent ions across the lamellae of swollen phospholipids. J Mol Biol. 1965; 13: 238-252.
12. Torchilin VP. Recent advances with liposomes as pharmaceutical carriers. Nat Rev Drug Discov. 2005; 4: 145-160.
13. Danhier F, Vroman B, Lecouturier N, Crokart N, Pourcelle V, Freichels H, et al. Targeting of tumor endothelium by RGD-grafted PLGA-nanoparticles loaded with paclitaxel. J Control Release. 2009; 140: 166-173.
14. Ochekpe NA, Olorunfemi PO, Ngwuluka N. Nanotechnology and Drug Delivery Part 2: Nanostructures for Drug Delivery. Trop. J. Pharm. Res. 2009; 8: 275–287.
15. Rawat M, Singh D, Saraf S, Saraf S. Nanocarriers: promising vehicle for bioactive drugs. Biol Pharm Bull. 2006; 29: 1790-1798.
16. Perche F, Torchilin VP. Recent trends in multifunctional liposomal nanocarriers for enhanced tumor targeting. J Drug Deliv. 2013; 2013: 705265.
17. Babu PJ, Saranya S, Sharma P, Tamuli R, Bora U. Sonocatalytic Synthesis of Gold Nanoparticles Using Ethnolic Extract of Andrographis paniculata and Functionalization with Gelatin-Polycaprolactone Composites. Front Mater Sci. 2012; 6: 236–249.
18. Calvo P, Remuñan-López C, Vila-Jato JL, Alonso MJ. Chitosan and chitosan/ethylene oxide-propylene oxide block copolymer nanoparticles as novel carriers for proteins and vaccines. Pharm Res. 1997; 14: 1431-1436.
19. El-Samaligy MS, Rohdewald P. Reconstituted collagen nanoparticles, a novel drug carrier delivery system. J Pharm Pharmacol. 1983; 35: 537-539.
20. Qiao W, Wang B, Wang Y, Yang L, Zhang Y, Shao P. Cancer Therapy Based on Nanomaterials and Nanocarrier Systems. J. Nanomater. 2010; 2010: 1–9.
21. Huh KM, Min HS, Lee SC, Lee HJ, Kim S, Park K. A new hydrotropic block copolymer micelle system for aqueous solubilization of paclitaxel. J Control Release. 2008; 126: 122-129.
22. Liu B, Yang M, Li R, Ding Y, Qian X, Yu L, et al. The antitumor effect of novel docetaxel-loaded thermosensitive micelles. Eur J Pharm Biopharm. 2008; 69: 527-534.
23. Kagaya H, Oba M, Miura Y, Koyama H, Ishii T, Shimada T, et al. Impact of polyplex micelles installed with cyclic RGD peptide as ligand on gene delivery to vascular lesions. Gene Ther. 2012; 19: 61-69.
24. Babu PJ, Saranya S, Sharma P, Tamuli R, Bora U. Green Synthesis and Characterization of Biocompatible Gold Nanoparticles Using Solanum indicum Fruits. Nanomaterials and Nanotechnology; 2013; (4): 1-7.

25. Babu PJ, Sharma P, Saranya S, Bora U. UV Light mediated synthesis of gold nanoparticles using ethonolic leaf extract of Bacopa monnieri. Materials Letters. 2012; 93: 431–434.

26. Doria G, Conde J, Veigas B, Giestas L, Almeida C, Assunção M, et al. Noble metal nanoparticles for biosensing applications. Sensors (Basel). 2012; 12: 1657-1687.

27. Qian X, Peng XH, Ansari DO, Yin-Goen Q, Chen GZ, Shin DM, et al. *In vivo* tumor targeting and spectroscopic detection with surface-enhanced Raman nanoparticle tags. Nat Biotechnol. 2008; 26: 83-90.

28. Vyas SP, Quraishi S, Gupta S, Jaganathan KS. Aerosolized liposome-based delivery of amphotericin B to alveolar macrophages. Int J Pharm. 2005; 296: 12-25.

29. Choi Y, Thomas T, Kotlyar A, Islam MT, Baker JR Jr. Synthesis and functional evaluation of DNA-assembled polyamidoamine dendrimer clusters for cancer cell-specific targeting. Chem Biol. 2005; 12: 35-43.

30. Liu Z, Chen K, Davis C, Sherlock S, Cao Q, Chen X, et al. Drug delivery with carbon nanotubes for *in vivo* cancer treatment. Cancer Res. 2008; 68: 6652-6660.

31. Tseng YY, Kao YC, Liao JY, Chen WA, Liu SJ. Biodegradable drug-eluting poly[lactic-co-glycol acid] nanofibers for the sustainable delivery of vancomycin to brain tissue: *in vitro* and *in vivo* studies. ACS Chem Neurosci. 2013; 4: 1314-1321.

Austin J Nanomed Nanotechnol - Volume 3 Issue 1 - 2015
ISSN : 2381-8956 | www.austinpublishinggroup.com

Citation: babu PJ, Saranya S and Mallepogu V. Nanoformulations as Drug Delivery Vehicles for Cancer Treatment. Austin J Nanomed Nanotechnol. 2015;3(1): 1038.