Chapter 11

Multifunctional Nanocarrier Systems for Effective Delivery of Drugs in Cancer Treatment

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ABSTRACT

The drug delivery to the cancer sites, with maintained effective drug concentration for longer duration, using low dose of drug, with minimum side effects is the prime concern of formulation scientist today. In the recent times, the nanocarrier systems are not only being utilized for achieving targeted, sustained and controlled release of drug to the disease site, but also are used in imaging of diseases. An attempt has been made through this chapter to give a brief outline about the cancer and elaborate details on the various multifunctional nanocarriers researched till date for effective delivery of drugs in cancer treatment. Further, functionalization and surface modification of nanocarrier with various ligands like folate, transferrin, TPGS (d-α- Tocopheryl Polyethylene Glycol 1000 Succinate), trastuzumab and hyaluronic acid etc., that have specific receptor in the proximity of disease site have been explained along with pros and cons of such carrier systems.

INTRODUCTION

The delivery of drugs to specified cancer sites, in early phase of disease, in safe and effective mode, with drug concentration in therapeutic range, over a period of time is needed to mitigate the disease consequence and this could be possible with carrier system and that can target the cancer site (Cerqueira, Lasham, Shelling, & Al-Kassas, 2017; Kushwaha, Ghoshal, Rai, & Singh, 2013; Singh, Sharma, Singh, Kumar, Pandey, Koch, & Muthu, 2016). However, the existing drug delivery approaches do not fully meet the criteria; therefore development of an effective drug carrier system to effectively deliver drugs and treat cancer or other diseases is inevitable.

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Cancer

Cancer is stated as uncontrolled proliferation of cells and better known disease to almost all populations of the world. The development of cancer cells is different from normal healthy cells (Dhas, Ige, & Kudarha, 2015). Despite of availability of treatment approaches like chemotherapy, an effective method is not yet found to eradicate the cancer and the failure of chemotherapy may be due to non-specificity as well as inability of the anticancer agent(s) to target the cancer cells. Cancer can affect different organs of the body and leads to cancer of liver, lung, breast, prostate, gall-bladder, ovary, pancreas and colon etc (Sheikhpour, Golbabaie, & Kasaeian, 2017). About 7.6 million deaths (approximately 13% of all deaths) occurred in 2008 because of cancer, as per the recent fact sheet of World Health Organization (WHO) wherein approximately 70% deaths happened in low and middle income countries. By 2030, cancer deaths are expected to rise over 13.1 million, worldwide (Mehra & Jain, 2015). Cancer treatment is a challenging task because; chemotherapeutic agents are cytotoxic in nature and could rarely differentiates healthy cells from cancer cells. Thus, leads to damage of vital normal organ cells in addition to killing cancer cells even at therapeutic drug concentration range, if their distribution in the body is not properly maintained and targeted towards the cancer cells or tissues (Modi, Patel, Desai, & Murthy, 2011). Therefore, targeted drug delivery to target cancer sites is essential need of the hour.

Drug Delivery

Almost all the present, chemotherapeutic agents are having low molecular weight with good pharmacokinetic volume of distribution, both of them bestow to their cytotoxicity and make them easily excreted. Their low therapeutic index does not offer favourably to this issue, as the required concentration for the better efficacy should be maintained, therefore higher drug concentration is needed and consequently toxicity is inevitable but unfortunately the therapeutic levels often exceeds. Further, these drugs administered alone, possess lack of specificity and cause notable damage to healthy tissues (Bharali, Khalil, Gurbuz, Simone, & Mousa, 2009). The aim of today’s researchers is to fabricate novel drug carrier systems to address the problems associated with existing non-functionalised nanoparticle therapy, such as high dose size, dosing frequency, lack of specificity and side effects etc. This objective driven the formulation scientists to fabricate a novel delivery approaches for effective delivery of drugs to cancer site and could be achieved by early detection/diagnosis/imaging of the cancer by ligand decorated multifunctional nanocarrier systems (Gindy & Prud’homme, 2009).

Nanocarrier System

The researchers have explored various micro and nanoparticulate carrier systems to overcome the problems associated with conventional chemotherapy in cancer. Different types of nanoparticulate system are available, such as polymeric nanoparticles, solid lipid nanoparticles, metal nanoparticles, liposomes, niosomes, nanofibers, nanocrystals, polymeric micelles, carbon nanotubes, nanostructured lipid carrier, quantum dots, dendrimers and lipoproteins etc (Torchilin, 2007). These carriers have become one of the most prominent systems for the diagnosis, treatment and prevention of cancer.

Loading of drugs in the nanocarrier system would protect them from the body’s natural defences and improves their availability at disease site. In addition, nanoparticles offer high drug payload and can also be surface modified with various types of ligands that could act as targeting moieties to reach the desired...
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