Chapter 12
Vaccine Nanocarriers:
The Future Ahead

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ABSTRACT

Vaccination has undergone a complete revolution over the past ten decades. With the progress in biotechnology, the present scientific world has witnessed the emergence of a novel vaccine delivery system, called nanovaccines, for eliciting effective humoral, cellular, and mucosal immunity as compared to the conventional vaccination strategies. This novel approach bears innovative methodologies for effective vaccination by arousing beneficial host responses. The different forms of nanovaccine delivery are either microspheres or nanobeads. This chapter discusses in detail the variant forms of nanoparticulate vaccine adjuvants and delivery systems, their interaction with the immune system, and their clinical trial results. Many nanovaccines licensed for human use have proved to be effective carriers for antigens. These immunopotentiators like virosome-based carriers, Immunostimulating Complexes (ISCOMs), polymeric particles, etc. can be formulated as new vaccination methods for curing diseases like HIV, malaria, hepatitis, cancer, etc., thereby cementing the future of the next generation vaccines.

INTRODUCTION

With new ventures in physical, chemical and biological sciences; a new dimension to matter at nano-scale is being explored lately. Nanotechnology is increasingly being considered to be the technology of the future. With this technology, researchers and scientists are now interested to incorporate and exploit materials at the atomic and molecular scale without hampering their essential properties. "Nano" is derived from a Greek word meaning "dwarf". It is a description for anything miniaturist or very small and the technology is generally defined as the science of understanding and restructuring matter in the range nanometers (i.e., less than 100 nm where one nanometer is equal to one-billionth of a meter) to create devices with new properties and targeted functions (Al-Deen, Ho, Selomulya, Ma, & Coppel, 2011; Ball, 2000; Donner, 2010; Grunze,

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2008; Zolnik, Gonzalez-Fernandez, Sadrieh, & Dobrovolskaia, 2010). The conceptual ideas of nanotechnology were explained first by Richard Feynman in his influential talk, "There's plenty of room at the bottom". The idea of experimentation came from the industries that targeted to design small, complex and faster electronic devices on silicon chips. The term nanotechnology did not become familiar until a scientist at the University of Tokyo, Norio Taniguchi, in 1974 threw light on the skill to fabricate materials accurately at the nanometer level. Generally, the sophistication behind nanotechnology involves two approaches; firstly where large sized structures are reduced to nanoscale retaining their originality and functional properties and secondly, the approach called ''molecular nanotechnology" (Fahy, 1993; Grunze, 2008; Plebanski & Xiang, 2013) where self assembly of matter engineered from atomic components or molecules are processed.

The aim of this emerging technology is the production, characterization and assembly of components on nanometer scale for bringing about radical changes in this scientific era. This will create a new generation of customized and multifunctional devices with an alloy of properties integrated into whole to enable these future machines to shine with exceptional performance and greater durability. The multidisciplinary branch of nanotechnology encompasses the techniques derived from engineering, physics, chemistry and biology which have led to the birth of this versatile technology. Nanotechnology has incorporated the fundamental and innovative concepts of basic science into material technology with an idea to have an array of applications for human welfare. With intense research and development; nanotechnology has begun to burgeon in this century giving rise to new advancement in the scientific industry (Ball, 2000; Bogunia-Kubik & Sugisaka, 2002).

The present world has witnessed the explosive development of this science as it has not only proven to be a boon for human health care but also for the advancement in communications, in engineering, genomics, robotics, chemistry, physics, energy production, medicines etc. Nanoscience has also immense potential to bestow benefits in diverse areas like textiles, water decontamination, information technologies, drug development, disease diagnosis, molecular biology, organic and synthetic chemistry. The dawn of nanotechnology can guarantee myriad of opportunities for the progress of medical science and treatment of complex diseases and disorders in human health care (Harrington, 2006; Hilt, 2004; Staiano et al., 2010). Nanotechnology can maximize the efficiency of therapeutic treatments in a million of ways since they target directly at the site of action sparing the healthy cells, bringing about the cure in an effective manner and improving the quality of an individual's life. In medicine and physiological applications, nanotechnology can aim to use materials that are designed to be biocompatible and can interact with body at molecular level with high specificity and sensitivity. This interaction can then be explored at the cellular and tissue level which can be targeted to achieve efficient therapeutic treatment thereby lessening the side effects (Hilt, 2004; Staiano et al., 2010).

In the last two decades nanotechnology has emerged as a revolutionary weapon to challenge the field of pharmacology with its innovations and advancements for the delivery of biologically active compounds. Nanoparticles conceptually can be assembled and designed in an intricate manner to be used for human benefits. Their small size eases their mode of entry since particle size really affects the administration of drug or vaccine and their efficacy in medical applications. It not only increases the availability of the vaccine/ drug but assists in the timely release of the molecule at accurate site highlighting its specificity (Nie, 2009). Nano-mediated drug delivery or vaccine delivery is the key technology which is cementing its stand for the future. It's important to have a deep knowledge of the biological properties of the cellular membranes and the physiochemical characteristics of the nanoparticle before the design

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