Chapter 5
Lipid Nanocarriers for Advanced Therapeutic Applications

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ABSTRACT

Lipid nanocarriers are the mainstream of nanotechnology-based advanced healthcare systems. This field has reported extensive research activity, promising results, and market acceptability over the past few decades. This profound success of lipid nanocarriers as therapeutic delivery systems is a result of their unique properties, that is, biocompatibility and biodegradability, possible delivery by multiple routes of administration, ease of formulation and scale up, amicable dosage form development, enhanced stability, bioavailability, and possible drug targeting. The chapter aims to give a detailed overview of various types of lipid nanocarriers along with methods of fabrication and characterization. The chapter also describes multiple applications of lipid nanocarriers in advanced therapeutics and elaborates on the current market opportunities and future prospects.

INTRODUCTION

Nanotechnology has revolutionized the face of modern day pharmaceuticals. Among various types of nanocarriers, lipid nanocarriers have attracted remarkable attention and have become market reality in very short duration. This practical success of lipid nanocarriers has resulted from their unique properties like biodegradability, possible delivery by multiple routes of administration, amicable dosage form development, enhanced stability, bioavailability and possible drug targeting along with their commercial feasibility in terms of ease of formulation development, scale up and characterization. Through extensive research over the years, various types of novel and effective lipid nanocarrier systems have been...

DOI: 10.4018/978-1-5225-4781-5.ch005
invented and are extensively researched. A detailed overview of these multitude lipid nanocarriers along with their manufacturing methods, characterization techniques and applications in advanced healthcare system are discussed in subsequent sections.

**TYPES OF LIPID NANOCARRIERS**

Researchers have explored an extensive number of lipid nanocarriers over the last several decades as described below. Their broad classification is depicted in Figure 1.

**Emulsion Based Lipid Nanocarriers**

The pictorial representation of emulsion based lipid nanocarriers is shown in Figure 2.

**Microemulsions, Nanoemulsions, and Multiple Emulsions**

In 1943, Schulman and Hoar introduced the concept of the microemulsion (Pappinen & Urtti, 2016). Microemulsions are kinetically and thermodynamically stable, spontaneously formed colloidal dispersions of oil and water stabilized by an interfacial film of alternating surfactant and co-surfactant molecules. They are of 10-140 nm size, transparent, optically isotropic, self-preserving, sterilizable and have ultra-low interfacial tension (Agrawal & Agrawal, 2012). Their advantages include, low cost of production, good stability, easy scale-up, high drug solubilization capacity and drug protection (Prabhu & Patravale, 2014).

Winsor has classified microemulsion system based on their phase equilibrium as shown in Table 1 (Moulik & Kumar, 2008). Further, microemulsion type can be determined by surfactant critical packing ratio (CPP) which can be calculate using Equation 1 (Prabhu & Patravale, 2014).

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\text{Critical Packing Ratio (CPP)} = \frac{V_o}{A \times l}
\]  

wherein ‘Vo’ is the volume of surfactant molecule, ‘A’ is the head group surface area and ‘l’ is the surfactant tail length.

For microemulsions, the oily phase is selected based on its biocompatibility, acceptability for the desired delivery route, drug solubilization capacity, ease of emulsification and additional benefits like P-GP efflux inhibition and oxidation stability etc. The surfactant is chosen on its biocompatibility, stabilization ability, chemical nature, acceptability for the desired delivery route, drug solubilization capacity and cloud point. Co-surfactant is selected based on its properties to decrease surface tension, increase interfacial fluidity and synergistically aid surfactant to stabilize microemulsion (Moulik & Kumar, 2008). Multiple mechanisms are involved in drug release from microemulsions and are depicted in Figure 3 (Pappinen & Urtti, 2016).

Nanoemulsions are kinetically stable colloidal dispersions of oil and water stabilized by an interfacial film of alternating surfactant and co-surfactant molecules with average size of 100nm and above. Unlike microemulsions, they are not thermodynamically stable and require energy intensive manufacturing tech-