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Growth of Nanostructures for Drug Delivery Applications: A Review Article

Neelanchanal Trivedi
Department of Pharmacy
Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India

ABSTRACT: ***The integration of nanostructures and drug delivery, with the rapid growth of nanotechnology, has become a research hotspot in recent years. Due to their specific and superior properties, different nanostructures are able to significantly increase the solubility of poorly soluble drugs, decrease cytotoxicity to normal tissues, and enhance therapeutic efficacy, in particular those developed from self-assembly. In the delivery of diverse drugs, such as small molecules, peptides, proteins and nucleic acids, nanostructures have been successfully applied. The driving forces for the self-assembly of nanostructures are introduced in this article. The approaches of drug delivery by nanostructures are discussed briefly. In addition, a number of nanostructures developed from different building materials, primarily liposomes, polymers, ceramics, metals, peptides, nucleic acids, and even drugs themselves, are emphasized. Due to their special and superior properties compared to traditional bulk materials, nanostructures have attracted intensive research attention in the past few decades. In a broad range of areas, such as materials, electronics, sensing, catalysis, climate, and drug delivery, they have been applied.***

KEYWORDS: ***Drugs, Delivery, Materials, Nanostructures, Research, Nanoparticles, Cytotoxicity.***

INTRODUCTION

In drug delivery systems, some of the challenges which need to be faced include bioavailability, in vivo stability, solubility, and absorption, sustained and targeted delivery to site of action, therapeutic efficacy, side effects, and fluctuation of drug concentration in plasma. To surmount these challenges, large quantities of studies have been carried out to explore the fabrication and application of various nanostructures in drug delivery [1].

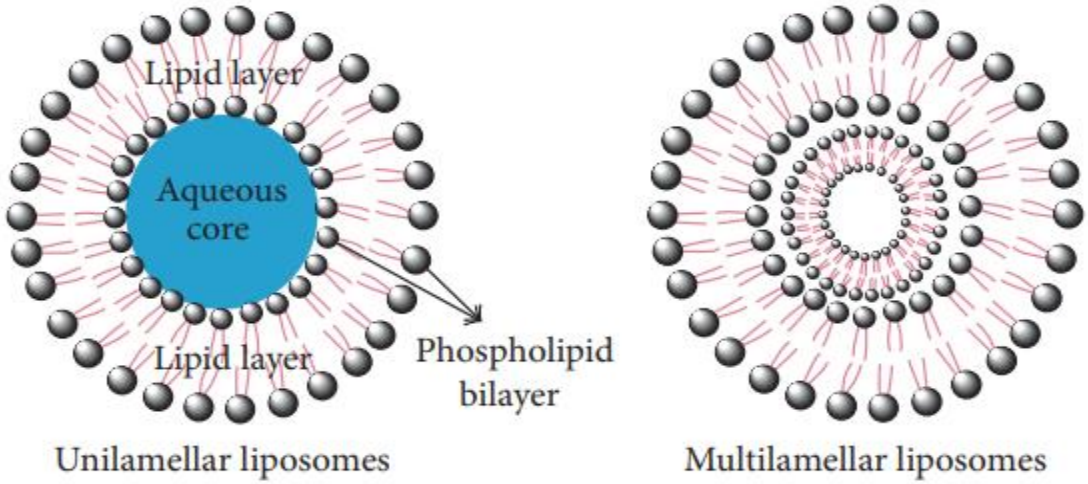

Figure 1: Illustrates diagram of elementary structures and different types of liposomes [2]

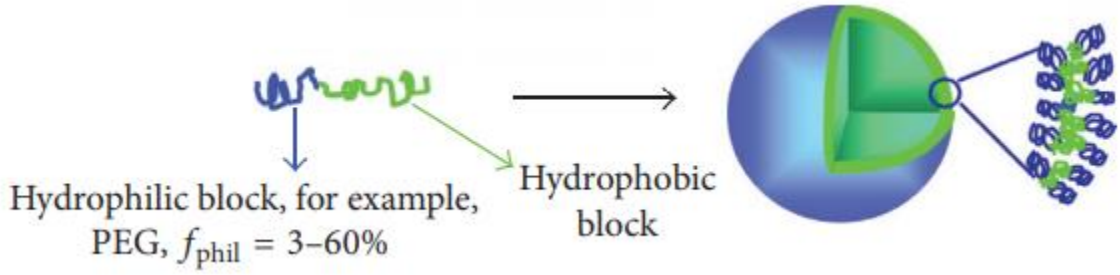

Figure 2: Illustrates the polymeric vesicles derived from asymmetric block copolymers [3]

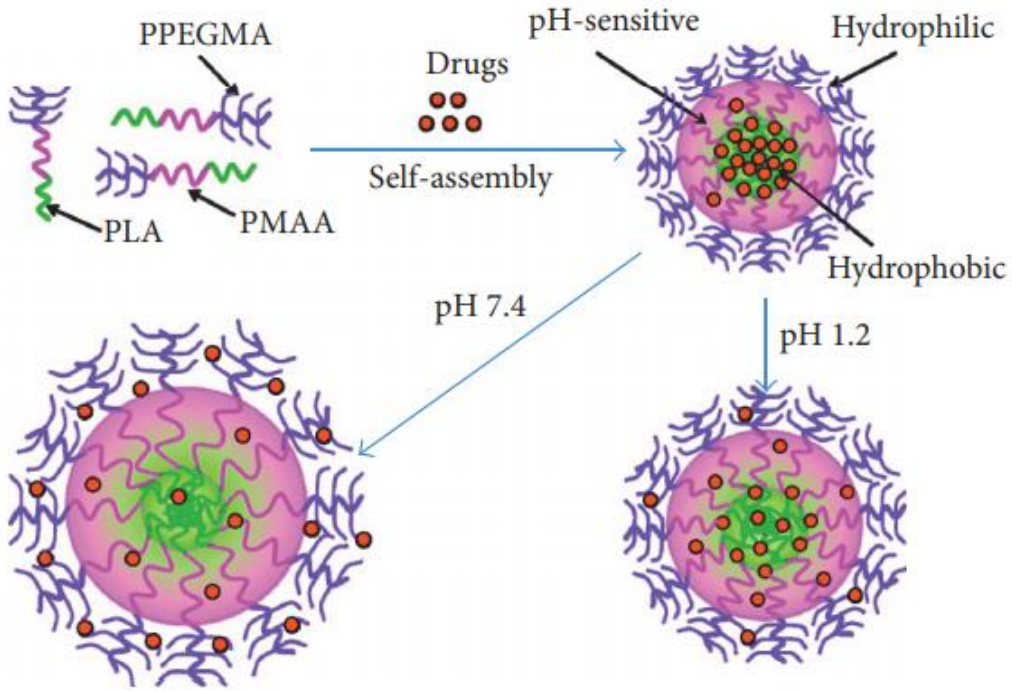

Figure 3: Illustrates the schematic drawing of drug loading

Active research on nanostructures in drug delivery is under way to address all these problems and challenges. It is a common assumption that future advancement in drug delivery applications can solve current problems with nanostructures [4]. Given the fact that people are still hesitant to adopt emerging innovations, nanotechnology can lead to changing the minds of the general public with various advantages. Fullerenes may also function as drug vectors or drug delivery scaffolds with noncovalent linkages or with covalent linkages between the fullerene and a bioactive moiety as nano molecular carbon cages. Fullerenes have turned out to be able to act as drug carriers after proper functionalization, such as adding hydrophilic moieties [5].

The hydrophobic effect is the most significant among various noncovalent interactions in the self-assembly process. Amphiphilic molecules, like many synthetic building blocks and biomolecules such as proteins and lipids, are a large variety of self-assembly building blocks. The self-assembly of amphiphilic molecules can be easily achieved by micro phase separation powered by thermodynamics due to the coexistence of polar and nonpolar regions [6]. The nonpolar regions of the building blocks will collapse and cluster together in aqueous solutions to expose water to the smallest possible hydrophobic area, while the Polar Regions try to optimize their contact with water [7].

DISCUSSION

Nanostructures used in drug delivery are typically built using the "bottom-up" approach, which is accomplished through the creation or assembly of building blocks. It is noteworthy that through the self-assembly of building blocks, a significant proportion of nanostructures are produced. Different types of noncovalent interactions play important roles in the self-assembly processes, based on the properties and structures of building blocks, and contribute to the stability of the resulting nanostructures [8].

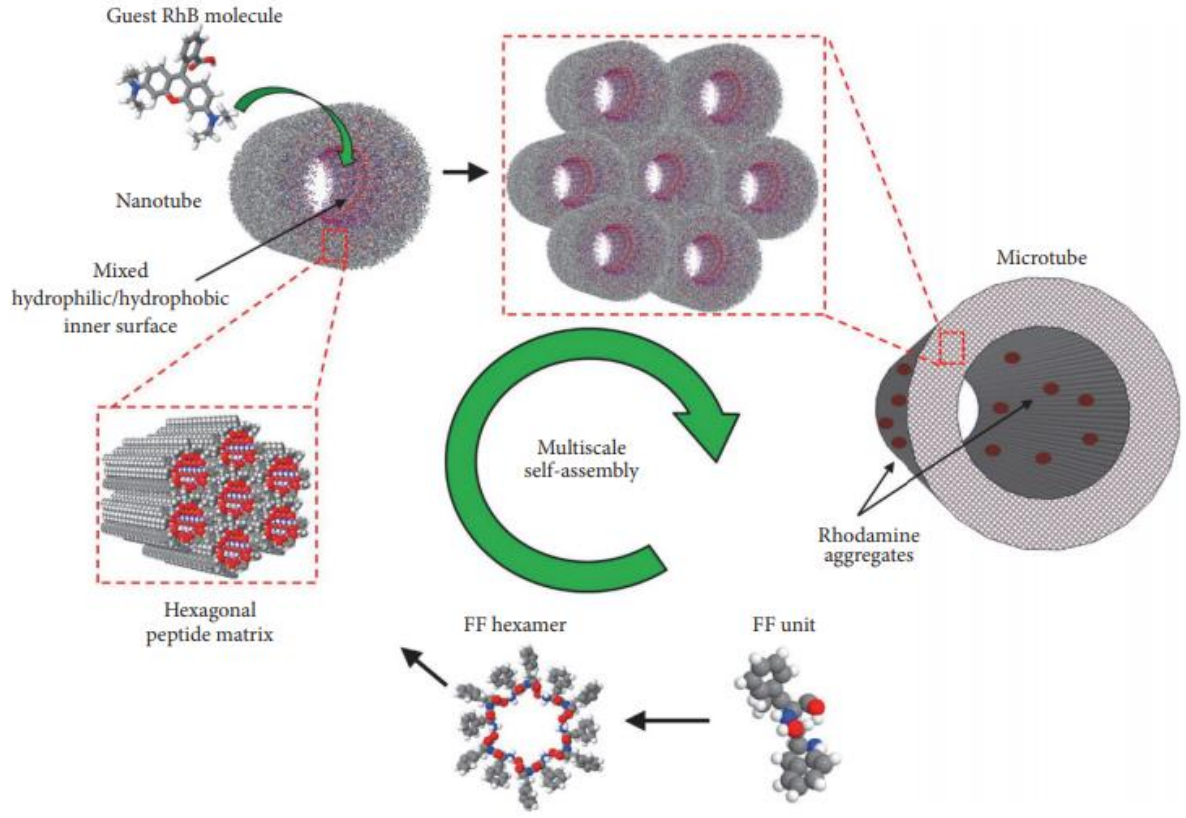

Figure 4: Illustrates the schematic depiction of the multiscale self-assembly of the FF-microtubes [9]

Passive delivery of drugs as 'cargoes' by nano carriers is the most common technique in the delivery process. By either physical encapsulation or chemical conjugation, the link between drugs and nano carriers is achieved. In the meantime, self-delivery is another option that constructs nanostructures with drug molecules themselves instead of just "cargoes" that need to be shipped from drug molecules [10]. Figure 1 illustrates the diagram of elementary structures and different types of liposomes. Figure 2 illustrates the polymeric vesicles derived from asymmetric block copolymers. Figure 3 illustrates the schematic drawing of drug loading. Figure 4 illustrates the schematic depiction of the multiscale self-assembly of the FF-microtubes.

CONCLUSION

These years, nanostructures have become more and more commonly used in drug delivery because of their special and useful properties. They have the benefits of increasing the solubility of poorly soluble medicinal products, reducing side effects, enhancing the effectiveness of existing medicinal products, etc. What is more, the spectrum of nanostructure options for the drug delivery system has been greatly expanded due to the great variety of nanostructures. However, several challenges are also faced by nanostructures for drug delivery, such as scaling up, expense, and safety issues. Compared with conventional drug delivery vehicles, the manufacturing system and procedure of several nanostructures are very complicated. Though nanostructures use far less materials than bulk delivery materials, the entire cost of manufacturing is often uneconomic, which is another major obstacle. More significantly, there is currently only limited knowledge on the effect of nano structural properties on organisms. Around the globe, the use of nanostructures in drug delivery has raised concerns.

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