Nanotechnology in the Life Sciences

Indu Bhushan
Vivek Kumar Singh
Durgesh Kumar Tripathi *Editors*

Nanomaterials and Environmental Biotechnology

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Nanotechnology is considered as one of the emerging fields of science. It has applications in different biological and technological fields which deal with the science of materials at nanoscale (10^{-9}). On the other hand, biotechnology is another field that deals with contemporary challenges. Nanobiotechnology fills the gap between these two fields. It merges physical, chemical, and biological principles in a single realm. This combination opens up new possibilities. At nanoscale dimensions, it creates precise nanocrystals and nanoshells. Integrated nanomaterials are used with modified surface layers for compatibility with living systems, improved dissolution in water, or biorecognition leading to enhanced end results in biotechnological systems. These nanoparticles can also be hybridized with additional biocompatible substances in order to amend their qualities to inculcate novel utilities. Nanobiotechnology is used in bioconjugate chemistry by coalescing up the functionality of non-organically obtained molecular components and biological molecules in order to veil the immunogenic moieties for targeted drug delivery, bioimaging and biosensing.

This book blends the science of biology, medicine, bioinorganic chemistry, bioorganic chemistry, material and physical sciences, biomedical engineering, electrical, mechanical, and chemical science to present a comprehensive range of advancements. The development of nano-based materials has made for a greater understanding of their characterization, using techniques such as transmission electron microscope, FTIR, X-ray diffraction, scanning electron microscope EDX, and so on. This volume also highlights uses in environmental remediation, environmental biosensors and environmental protection. It also emphasizes the significance of nanobiotechnology to a series of medical applications *viz.*, diagnostics, and therapeutics stem cell technology, tissue engineering enzyme engineering, drug development and delivery. In addition this book also offers a distinctive understanding of nanobiotechnology from researchers and educators and gives a comprehensive facility for future developments and current applications of nanobiotechnology.

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Chapter 13
Solid Lipid Nanoparticles

Akhlesh Kumar Jain and Suresh Thareja

13.1 Introduction

The area of Novel Drug Delivery System is getting wider day by day in expanded area of biomedical science, bioengineering and nanotechnology (Ekambaram et al. 2012). Most of the latest delivery techniques explore nanosize-based particles, i.e. nanocarriers having the API (Shah et al. 2011). Few important drug carriers developed using nanotechnology-based approaches are nanoemulsion, nanosuspension, nanocrystals, nanoparticles and solid lipid nanoparticles (Jain 1997). Recent advances in the development of nanocarriers have started a new era in Formulation Science. Solid lipid nanoparticles (SLNs) were reported in 1991 as an unconventional carrier system to typical colloidal carriers such as emulsions, microemulsions, self micro-emulsifying drug delivery system, micellar systems, liposomes, polymeric microparticles and nanoparticles (Ramteke et al. 2012).

SLNs mingle advantages of the conventional carriers along with circumventing some of their major disadvantages. SLNs showed potential applications in drug, gene and vaccine delivery along with controlled and site-specific drug targeting. SLNs are effortlessly made nanoparticles composed of biodegradable polymers of high stability devoid of significant toxicity as well as commercially economic and could incorporate wide variety of drugs for effective targeting. SLNs are novel lipid-based formulations constituted exclusively of biodegradable lipids such as highly purified triglycerides, monoglycerides, complex glyceride mixtures, hard fats or even waxes, which turn solid at room temperature. Solid lipid nanoparticles are nanometre-sized particles that range from 50 to 200 nm and made of solid hydrophobic core which are suspended in aqueous phase containing surfactant.

A. K. Jain (✉) · S. Thareja
School of Pharmaceutical Sciences, GGV Central University, Bilaspur, Chhattisgarh, India

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The drug is dissolved or dispersed in the core contains the solid high melting matrix. Both kinds of lipophilic or hydrophilic therapeutics and diagnostics be incorporated into the SLN (Shah et al. 2011). SLNs not only unite the advantages of emulsion, liposomes and solid polymeric nanocarriers together but also eliminate few of their disadvantages. Major advantages included are biocompatibility, biodegradability, avoidance of drug leakage, stability against coalescence, hydrolysis, physical stability and being an excellent carrier for lipophilic drugs (Cavalli et al. 2002). Lipid emulsion and liposomes are entirely different. Oil made of a neutral lipid, covered by monolayer of amphiphilic lipid, makes emulsion, whereas liposomes are bilayer lipid vesicles made of amphiphilic phospholipid having an interior aqueous cavity (Jain 1997). On the other hand, SLNs designed from solid lipids and stabilized with an aqueous suspension of emulsifying agents. They look a lot like nanoemulsion; the only difference is that liquid lipid replaced with a solid lipid, hence providing an outstanding opportunity for controlled drug release as solid lipid lowers the movement of encapsulated drug drastically compared to liquid oil phase (Martins et al. 2007). Also, encapsulation in solid lipids improves the stability of incorporated chemically sensitive lipophilic ingredients in contrast to liquid lipids of nanoemulsion. These prospective benefits of physicochemical properties associated with the physical state of the lipid phase are as follows:

(i) Movement of reactive radicals in solid material is slower compared to liquid medium and hence limits the degradation pathways.
(ii) Phase partition of the API and lipid phase into the solid lipid thus prevents leaching of drugs at the surface of SLN.
(iii) Enhanced absorption of inadequately absorbed drugs is reported after administration using SLN.

Large-scale production of SLNs could be achieved out in a cost-effective and relatively simple manner using high-pressure homogenization technique. Another approach for the production of SLNs is microemulsions or simply suspending liquid lipid in a solution of surfactant with stirring and sonication. SLNs made using various methods are present in suspension form; hence storing for prolonged period of time showed instability due to hydrolysis reactions. However conversion of SLNs into dry powder which can be reconstituted in order to improve stability of SLNs with the help of lyophilization or spray drying, is an excellent way (Sinha et al. 2010). SLNs provide an excellent opportunity as an advanced drug carrier for oral delivery, topical administration, pulmonary administration, parenteral administration, gene delivery and potential adjuvant for vaccines. In a nutshell, they propose an extremely versatile platform for second- and third-order targeting of drugs.

The major advantages associated by SLNs are as follows:

(a) Suitable for controlled drug release and drug targeting.
(b) Suitable for delivery of both hydrophilic and lipophilic drugs.
(c) Reduced toxicity compared to polymeric nanoparticles as SLNs are made of biocompatible lipids.