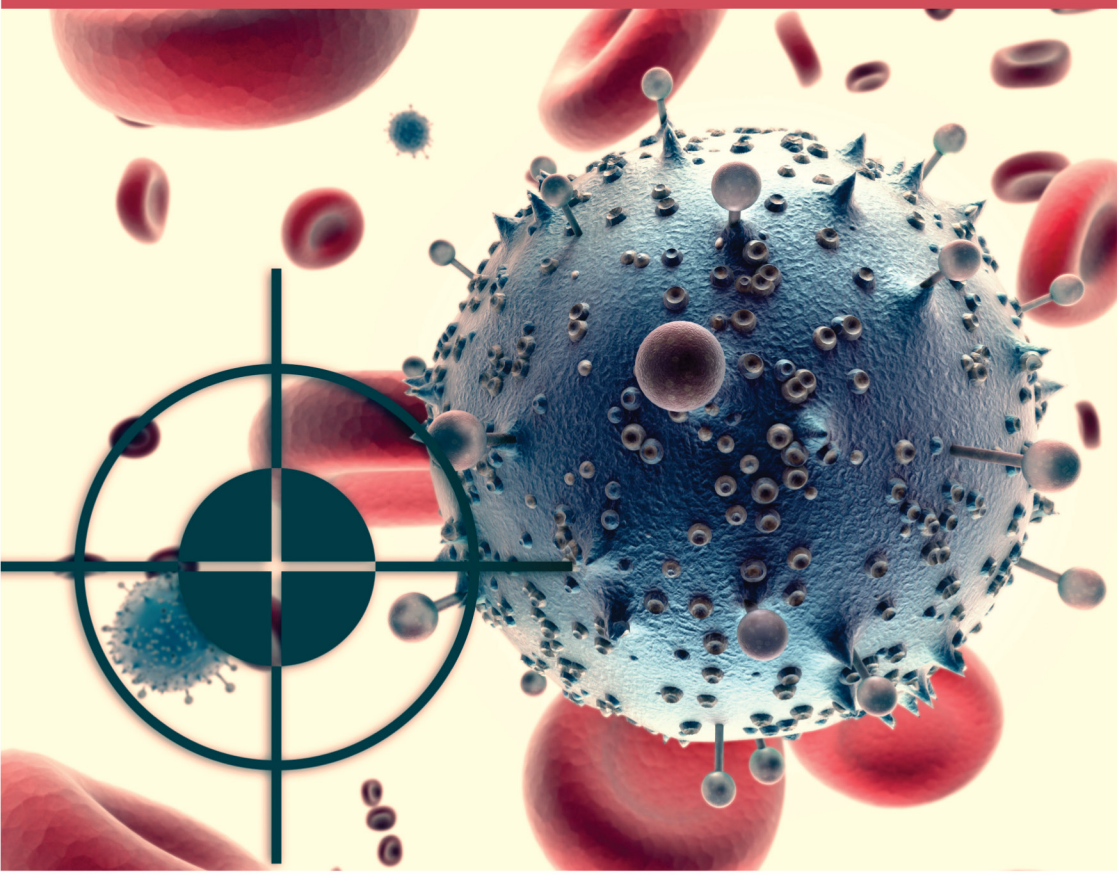
Nanoparticulate Drug Delivery Systems



Raj K. Keservani | Anil K. Sharma
Editors

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Edited by
Raj K. Keservani, MPharm
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The Present Book is Dedicated to
Our Beloved
Aashna, Anika, Atharva, and Vihan

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ABBREVIATIONS

αCD	α-cyclodextrin
5-FU	5-fluorouracil
6-OHDA	6-hydroxydopamine
Aβ	amyloid beta
Ab	antibody
ACF	aceclofenac
ACh	acetylcholine
AD	Alzheimer's disease
AFM	atomic force microscopy
AgNPs	silver nanoparticles
ALPZ	alprazolam
AMB	amphotericin B
AMT	amantadine
ANP	asenapine
API	active pharmaceutical ingredient
APM	apomorphine
APZ	aripiprazole
ASGP-R	asialoglycoprotein receptor
ATL	amitriptyline
AUC	area under the curve
BBB	blood–brain barrier
BPR	buspirone
BRC	bromocriptine
BSA	bovine serum albumin
CBZ	carbamazepine
CCM	curcumin
CDS	cyclodextrins
CLP	citalopram
ClTox	chlorotoxin
CMC	carboxymethyl chitosan
CNS	central nervous system
CNT	carbon nanotube
COMT	catechol-o-methyltransferase
CPM	clomipramine

CPZ	chlorpromazine
CS	chitosan
CTC	citicoline
CTX	chlorotoxin
CZP	clozapine
DA	dopamine
DAA	diacetyl apomorphine
DAP	diallyl phthalate
DIA	diisobutyryl apomorphine
DMP	domperidone
DNA	deoxyribonucleic acid
DNP	donepezil
DOX	doxorubicin
DPPG	dipalmitoylphosphatidylglycerol
DSC	differential scanning calorimetry
DXT	duloxetine
DXT–NLC	NLC-containing duloxetine
EC	ethylcellulose
ECM	extracellular matrix
EE	entrapment efficiency
EGF	epidermal growth factor
EGFR	epidermal growth factor receptor
EL	endosome/lysosome
EMA	European Medicines Agency
EPR	electron paramagnetic resonance
EPR	enhanced permeability and retention
ESR	electron spin resonance
ETC	entacapone
ETX	ethosuximide
FA	folic acid
FA–BSA	folate-conjugated bovine serum albumin
FALT	fixed aqueous layer thickness
FDA	Food and Drug Administration
FR	folate receptor
FXT	fluoxetine
GABA	γ-aminobutyric acid
GBP	gabapentin
GLT	galantamine
GLT–Ce-Hap	GLT ceria nanodots-containing hydroxyapatite
Glu-GNPs	glucose-bound GNPs

GM1-rHDL	monosialotetrahexosylganglioside-modified reconstituted high-density lipoprotein
GMS	glyceryl monostearate
GNPs	gold nanoparticles
GRAS	generally recognized as safe
GRAS	generally regarded as safe
HA	hyaluronic acid
HAS	human serum albumin
HMC	highly ordered mesoporous carbon
HPH	high-pressure homogenization
HPL	haloperidol
HPLC	high-pressure liquid chromatography
HSH	high-shear homogenization
HUVEC	human umbilical vein endothelial cells
HXZ	Hydroxyzine
i.n.	intranasal
i.p.	intraperitoneal
IC	intracoronary
Ig	immunoglobulins
IPD	Iloperidone
IPM	imipramine
LBDDS	lipid-based drug delivery systems
LCNs	lipid-core nanocapsules
LD	laser diffraction
LD	levodopa
LDH	lactate dehydrogenase
LE	lipid emulsions
LN	lipid nanoparticles
LNC	lipid nanocarriers
LRD	lurasidone
LTG	lamotrigine
MAO-B	monoamine oxidase B
MASSA	melatonin agonist and selective serotonin antagonist
MDR	multidrug resistance
ME	microemulsion
MFH	magnetic fluid hyperthermia
MIP	molecularly imprinted polymer
MLD	molecular layer deposition
MLNPs	magnetic luminescent nanoparticles
MMA	methyl methacrylate

MMPNs	multifunctional magneto-polymeric nanohybrids
MMT	montmorillonite
MMTN	memantine
MNEG	mucoadhesive oil/water nanoemulgel
MNPs	magnetic nanoparticles
MPS	mononuclear phagocyte system
MR	magnetic resonance
MRI	magnetic resonance imaging
MSCs	mesenchymal stem cells
MSN	mesoporous silica NPs
MTX	methotrexate
MVs	microvesicles
MW	molecular weight
MWCNTs	multiwalled CNTs
NAP	neuroprotective peptide
NAs	nucleic acids
NC	nanocapsules
NCLs	nanostructured lipid carriers
NEs	nanoemulsions
NGs	nanogels
NIPAM	N-isopropylacrylamide
NIR	near-infrared
NMDA	N-methyl-d-aspartate
NMR	nuclear magnetic resonance
NPLC	nanostructured polymeric lipid carriers
o/w	oil-in-water
OBZ	oxcarbazepine
OVA	ovalbumin
OZP	olanzapine
P4VP	poly(4-vinylpyridine)
PACA	polyalkyl cyanoacrylates
PAMAM	polyamidoamine
PBCA	polybutyl cyanoacrylate
PCL	poly-ε-caprolactone
PCS	photon correlation spectroscopy
PD	Parkinson's disease
PDA	polidopamine
PDI	polydispersity index
PECA	polyethyl cyanoacrylate
PECs	polyelectrolyte complexes

PEG	polyethylene glycol
PEI	polyethyleneimine
PEO	poly(ethylene oxide)
PEO–PPO–PEO	poly(ethylene oxide)–poly(propylene oxide)–poly(ethylene oxide)
PET	positron emission tomography
PG	poly-L-glutamic
P-gp	P-glycoprotein
PHB	polyhydroxybutyrate
PHP	perphenazine
PHT	phenytoin (PHT
PiBCA	polyisobutyl cyanoacrylate
PLA	polylactic acid
PLGA	poly(lactic-co-glycolic acid)
PMAA	poly(methacrylic acid)
PMMA	polymethyl methacrylate
PMS	PEG monostearate
PNBs	perfluorocarbon nanobubbles
PNIPAM	poly(N-isopropylacrylamide)
PNPs	polymeric NPs
PPD	paliperidone
PPSu	poly(propylene succinate)
PSMA	prostate-specific membrane antigen
PTT	photothermal therapy
PVA	poly(vinyl alcohol)
PVP	polyvinylpyrrolidone
PXT	paroxetine
QDs	quantum dots
QTP	quetiapine
RES	reticuloendothelial system
RGL	rasagiline
RHAMM	receptor for hyaluronate-mediated motility
RM	reverse micelles
RNA	ribonucleic acid
ROS	reactive oxygen species
RPD	risperidone
RPN	ropinirole
RTG	rotigotine
RVG	rivastigmine
SC	stratum corneum

SELEX	systematic evolution of ligands by exponential enrichment
SEM	scanning electron microscopy
SGL	selegiline
siRNA	small interfering ribonucleic acid
SLNPs	solid lipid nanoparticles
SLNs	solid lipid nanoparticles
SNEDDS	self-nanoemulsifying drug delivery system
SPD	sulpiride
SPIONs	superparamagnetic iron oxide nanoparticles
SSRIs	serotonin-specific reuptake inhibitors
STR	sertraline
SWCNTs	single-wall carbon nanotubes
SWNT	single-wall nanotube
TBARS	thiobarbituric acid reactive substances
TCR	tacrine
TEM	transmission electron microscopy
TfR	transferrin receptor
TGA	thioglycolic acid
TPP	tripolyphosphate
TRZ	trazodone
UV	ultraviolet
VEGF	vascular endothelial growth factor
VLF	venlafaxine
VPA	valproic acid
WHO	World Health Organization
XRD	X-ray diffractometry
ZNS	zonisamide
ZP	zeta potential
ZPD	ziprasidone

PREFACE

The existence of diseases/disorders his commenced from the beginning of civilization on the Earth. In the ancient world, the occurrences of morbidity and mortality used to be higher, and this was ascribed to be resulting from the wrath of deities, owing to ignorance among the society. Contemporary scientists have faced a lot of trouble while attempting to demonstrate the treatment potential of medicines. However, as science evolved further, the significance of drugs to cure and mitigate certain ailments has recieved acceptance from people to whom these have done wonders. Substantially, it was recognized that the active ingredients warranted to be dispensed as dosage forms, which usually comprised drugs and excipients.

There has been an overwhelming growth of nanotechnology in a variety of aspects that we routinely encounter. The uses of nanotechnology embrace materials science, engineering, medicine, dentistry, drug delivery, and so forth. The development relevant to the delivery of pharmaceutical active ingredients are of paramount concern for researchers working in domains of academia and industry.

In line with the above, the objective of this present book is to provide its readers updated knowledge about several nanoparticulate carriers. To accomplish this, the content of this book is written by adept, qualified, and well-known scientists and researchers from all over the world. The audience of the present book encompasses postgraduate students, researchers, academicians, scientists, and industrialists.

This book, **Nanoparticulate Nanocarriers Approaches in Drug Delivery**, is comprised of 12 chapters divided into four sections, which entail an introduction of nanoparticulate, nanocarriers, physicochemical features, generalized, and specific applications dealing with drug delivery in particular. The materials used, as well as formulation and characterization, have been discussed in detail. The emphasis of certain chapters is to provide the authors' specific input regarding treatment of a disease/disorder causing high mortality.

PART I: APPLICATIONS OF NANOPARTICLES

Chapter 1: Polymeric Nanoparticles: General Features, Polymers, and Formulation Aspects, written by Marcos Luciano Bruschi and colleagues,

introduces the terminology prevailing in nanoscience. Further, it provides an overview of various polymers explored for preparation of nanoparticles. Subsequent to this, techniques/procedures to formulate nanoparticles have been discussed.

The details of general principles of nanoparticles have been presented in Chapter 2: Nanoparticles in Drug Delivery: General Characteristics, Applications, and Challenges, written by Khushwinder Kaur. The chapter deliberates over the potential of nanoparticles in the treatment of diseases such as cancer, Alzheimer's, and so forth. Further, the challenges faced while attempting delivery through these nanocarriers are also described.

Chapter 3: Nanoparticles as Nanopharmaceuticals: Smart Drug Delivery Systems, written by Md. Sahab Uddin, gives an elaborated discussion of nanoparticles, covering a general introduction, characterization techniques, manufacturing, and classification of different nanoparticles. Future opportunities as well as challenges have been mentioned in the last section of the chapter.

A customized approach with respect to applications of nanoparticles in cancer is described by Chapter 4: Nanoparticles Advance Drug Delivery for Cancer Cells, written by Hani Nasser Abdelhamid and Hui-Fen Wu. The authors claim that this book chapter is a valuable reference source for those scientists working in the field of pharmaceutical sciences, medicine, bionanotechnology, materials science, biomedical sciences, and related areas of life sciences. They have focussed on the most relevant references and concisely summarize the findings with illustrated examples.

Chapter 5: Nanotechnology-Based Formulations for Drug Targeting to the Central Nervous Systems, written by Josef Jampílek and Katarína KráĽová, deals with specific targeting to organs/systems in the CNS. This contribution is focused on the effects and CNS targeting of nanoscale formulations containing drugs such as antiepileptics, antipsychotics, anxiolytics, antidepressants as well as drugs applied for treatment of schizophrenia and Parkinson's and Alzheimer's diseases. The benefits connected with their application (e.g., reduction of required drug dose at bioavailability increase, reduced side effects due to decreased toxicity against nontarget cells, prolongation of time in circulation) are highlighted as well.

PART II: METALLIC NANOPARTICLES

The description of various magnetic nanoparticles is given in Chapter 6: Magnetic Nanoparticles for Drug Delivery, written by Meenakshi Ponnana

and Lakshmi Kiran Chelluri. This chapter covers the physical and chemical properties, applications, their fabrication, enhanced targeting through passive, active, and physical magnetic targeting mechanisms, route of their administration through oral, parenteral, intranasal, dermal and transdermal routes, imaging capabilities, innovative approaches for using stem cells and their *in vivo* tracking. In addition, future perspectives and challenges faced by magnetic nanoparticles in the drug delivery and their scope have also been addressed.

Chapter 7: Overview of Applications of Gold Nanoparticles in Therapeutics, written by Juliana Palma Abriata and colleagues, provides an overview of specialized gold nanoparticles. The objective is to present and discuss some aspects of gold nanoparticles (GNP) development and its use in the drug delivery field. In the beginning, different types of GNP, its production methods, and characterization have been described. Then, the different functionalization options, using small molecules or macromolecules, are discussed. Finally, the stimuli-responsive GNPs are described. Interestingly, ongoing clinical trials have been presented in tabular form.

The uses of iron oxide nanoparticles for treatment of cancer have been discussed in Chapter 8: Superparamagnetic Iron Oxide Nanoparticles: Application in Diagnosis and Therapy of Cancer, written by Ljiljana Djekic. This chapter provides an overview of the main research aspects with respect to superparamagnetic iron oxide nanoparticles (SPIONs), including common approaches for magnetite core synthesis; main strategies for coating and functionalization of SPIONs surface with targeting ligands, imaging or therapeutic moieties, drug release mechanisms; the principles of their usage in magnetic fluid hyperthermia (MFH) and magnetic resonance imaging (MRI); and safety considerations. The potential for enhancement of diagnostic and therapy of cancer is described in detail.

PART III: LIPID-BASED NANOPARTICULATES

Chapter 9: Solid Lipid Nanoparticles: General Aspects, Preparation Methods, and Applications in Drug Delivery, written by Marcos Luciano Bruschi and colleagues, addresses widespread applications of lipid nanoparticles as carriers for different drugs. This chapter brings a combination of information from the beginning of the development of these systems, in the 1990s decade until modern studies, approaching the main preparation methods and also the lipid nanoparticle evaluation as drug delivery systems through different application routes. In addition, toxicity issues have also been mentioned in the last section of this chapter.

The focused information of solid lipid nanoparticles in the treatment of skin lesions is given by Chapter 10: Solid Lipid Nanoparticles in Drug Delivery for Skincare, written by Sheefali Mahant and associates. The present chapter provides a detailed account of solid lipid nanoparticles (SLNs) as dermal carriers, covering their composition, production, characterization, release profile, cosmetic benefits, and the studies carried out. A list of recent patents on SLNs for drug delivery in skin care has also been included.

PART IV: NEWER NANOARCHITECTURES

Chapter 11: Dendrimers in Gene Delivery, written by Bhupinder Kaur and colleagues, describes the applications of dendrimers in gene delivery. This chapter focuses on the basic mechanisms of gene delivery and dendrimer-based gene delivery. The variety of approaches for gene delivery are described in the beginning, then uses of branched polymeric structures for transfer of genetic information are provided.

An overview of nanoscience-based preparations of carbon nanotubes for the treatment of infections has been presented in Chapter 12: Carbon Nanotubes for Drug Delivery: Focus on Antimicrobial Activity, written by Márcia Ebling de Souza and associates. The authors have provided a general introduction of CNTs in the first half of chapter. The latter half deals with diverse uses of these carriers in control of various microorganisms. The conclusion summarizes the chapter with mention of future perspectives.