

Contents

<i>Contributors</i>	<i>xi</i>
<i>Preface</i>	<i>xv</i>
1. Stabilisation of Carbon Nanotube Suspensions	1
<i>Dimitrios G. Fatouros, Marta Roldob and Susanna M. van der Merwe</i>	
1.1 Introduction	1
1.2 Functionalised CNTs for Drug Delivery	4
1.3 Surface-Active Agents in Stabilising CNT Suspensions	5
1.4 Stabilisation of Aqueous Suspensions of Carbon Nanotubes by Self-Assembling Block Copolymers	9
1.5 Stabilisation of Aqueous Suspensions of Carbon Nanotubes by Chitosan and its Derivatives	12
2. Biomedical Applications I: Delivery of Drugs	23
<i>Giampiero Spalluto, Stephanie Federico, Barbara Cacciari, Alberto Bianco, Siew Lee Cheong and Maurizio Prato</i>	
2.1 Introduction	23
2.2 Non-Covalent Functionalisation on the External Walls	27
2.3 “Defect” Functionalisation at the Tips and Sidewalls	29
2.4 Covalent Functionalisation on the External Sidewalls	30
2.5 Encapsulation Inside CNTs	33
2.6 Conclusions and Perspectives	34
3. Biomedical Applications II: Influence of Carbon Nanotubes in Cancer Therapy	47
<i>Chiara Fabbro, Francesca Maria Toma and Tatiana Da Ros</i>	
3.1 Importance of Nanotechnology in Cancer Therapy	47
3.2 Carbon Nanotubes: A Brief Overview	51
3.3 Carbon Nanotubes as Drug Vectors in Cancer Treatment	52
3.4 Delivery of Oligonucleotides Mediated by Carbon Nanotubes	59
3.5 Carbon Nanotubes in Radiotherapy	64
3.6 Carbon Nanotubes in Thermal Ablation	66
3.7 Biosensors Based on Carbon Nanotubes	70
3.8 Conclusions	79

4. Biomedical Applications III: Delivery of Immunostimulants and Vaccines	87
<i>Li Jian, Gopalakrishnan Venkatesan and Giorgia Pastorin</i>	
4.1 Introduction to the Immune System	87
4.2 Immunogenic Response of Peptide Antigens Conjugated to Functionalised CNTs	88
4.2.1 Fragment Condensation of Fully Protected Peptides	89
4.2.2 Selective Chemical Ligation	91
4.3 Interaction of Functionalised CNTs with CPG Motifs and Their Immunostimulatory Activity	94
4.4 Immunogenicity of Carbon Nanotubes	96
4.5 Conclusions	100
5. Biomedical Applications IV: Carbon Nanotube–Nucleic Acid Complexes for Biosensors, Gene Delivery and Selective Cancer Therapy	105
<i>Venkata Sudheer Makam, Jason Teng Cang-Rong, Sia Lee Yoong and Giorgia Pastorin</i>	
5.1 Introduction	105
5.2 Interaction of CNTs with Nucleic Acids	106
5.3 Sensors and Nanocomposites	125
5.4 CNT–Nucleic Acid Complexes for Gene Delivery and Selective Cancer Treatment	132
6. Biomedical Applications V: Influence of Carbon Nanotubes in Neuronal Living Networks	151
<i>Cécilia Ménard-Moyon</i>	
6.1 Introduction	151
6.2 Effects of Carbon Nanotubes on Neuronal Cells' Adhesion, Growth, Morphology and Differentiation	153
6.3 Electrical Stimulation of Neuronal Cells Grown on Carbon Nanotube-Based Substrates	161
6.4 Investigation of the Mechanisms of the Electrical Interactions Between CNTs and Neurons	173
6.5 Conclusions and Perspectives	176
7. Biomedical Applications VI: Carbon Nanotubes as Biosensing and Bio-interfacial Materials	185
<i>Yupeng Ren</i>	

7.1	Introduction	185
7.2	Biosensor	186
7.2.1	Structure and Electric Properties of CNTs	186
7.2.2	CNTs as Electric Sensors	188
7.2.2.1	CNT-based electric devices	188
7.2.2.2	CNT-based sensors	190
7.2.2.2.1	<i>Mass/force sensor</i>	190
7.2.2.2.2	<i>Chemical sensors</i>	191
7.2.2.2.3	<i>Structure sensor</i>	195
7.2.2.2.4	<i>Electric probes</i>	196
7.2.2.2.5	<i>Microscope sensors</i>	197
7.2.2.2.6	<i>Liquid flow sensor: transfer momentum to current</i>	198
7.2.3	Fluorescence Emission, Quenching and Detection	198
7.2.3.1	Fluorescence emitter	199
7.2.3.2	Raman spectrum	204
7.2.3.3	Electric luminescence	204
7.2.3.4	Fluorescence quenching	204
7.2.3.5	Photoconductivity	207
7.3	Bio-interface	207
7.3.1	The Fundamental Properties for Bio-interface Application	207
7.3.2	Applications	209
7.3.2.1	Applications for bone tissue engineering	209
7.3.2.2	Applications for neural tissue engineering	212
7.3.2.3	Application for other cells and tissues engineering	212
7.4	Conclusions	213
8.	Toxicity of Carbon Nanotubes	223
<i>Tapas Ranjan Nayak and Giorgia Pastorin</i>		
8.1	Introduction	223
8.2	Parameters Responsible for the Toxicity of CNTs	224
8.2.1	Surface of CNTs	224
8.2.2	CNTs' Concentration	227
8.2.3	CNTs' Dispersibility	233
8.2.4	Length and Diameter	233
8.2.5	Purity	235

8.3	Environmental Exposure	236
8.4	Conclusion	242
9.	Overview on the Major Research Activities on Carbon Nanotubes being done in America, Europe and Asia	247
	<i>Cécilia Ménard-Moyon and Giorgia Pastorin</i>	
9.1	Introduction	247
9.2	America	248
9.2.1	USA	249
9.2.1.1	Electronic properties of CNTs	249
9.2.1.2	CNT-FETs	249
9.2.1.3	CNT nanophotonics	253
9.2.2	USA	255
9.2.2.1	Functionalisation of CNTs for biomedical applications	256
9.2.2.2	CNTs for bioimaging and biosensing	264
9.2.2.3	Electronics and optical properties of CNTs	267
9.2.3	USA	269
9.2.3.1	CNT sorting	269
9.2.4	USA	273
9.2.4.1	Synthesis of CNTs	273
9.2.4.2	Functionalisation of CNTs	276
9.2.4.3	Optical properties of nanomaterials	279
9.2.5	USA	282
9.2.5.1	CNT-based sensors	282
9.2.5.2	Single-particle tracking	287
9.2.6	Mexico	287
9.2.6.1	Doping of CNTs	288
9.2.6.2	Electrical properties of CNTs	290
9.2.6.3	Junctions between CNTs or between metals and CNTs	292
9.2.6.4	Incorporation of CNTs with different species	294
9.3	Europe	296
9.3.1	Drug Delivery and Other Biomedical Applications	296
9.3.2	Neuronal Applications	300
9.3.3	Photovoltaic Applications	302
9.3.4	Functionalisation of CNTs	303

9.4	Asia	304
9.4.1	Japan	304
9.4.1.1	Encapsulation and reactions inside CNTs	304
9.4.1.2	Synthesis of CNTs	310
9.4.2	Japan	312
9.4.2.1	Investigations on molecules@CNT conjugates	313
<i>Index</i>		335