NANOMATERIALS AND NANOSYSTEMS FOR BIOMEDICAL APPLICATIONS

Nanomaterials and Nanosystems for Biomedical Applications

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FOREWORD

It is not so far from now, although it is just the end of the XX century, the time when we discussed outlooks of the use of biotechnologies in medicine and pharmacy. These hopes were connected mainly with new microbiological products and new materials (polymers) for pharmaceutics, biomedicine and organ transplantation. Now in the XXI century, we are much more enthusiastic about outlooks of nanotechnologies for our life and environment. Nanotechnology, when fused with biotechnology, creates nanobiotechnology and nanobiomedical technology; the products of which hardly resemble the parent biotechnology products. These new scientific disciplines, by overall opinion, can even change the face of our civilization in this century. The important point is that dealing with nanotechnologies, we faced new phenomenon: the transition of compounds to nanostate dramatically changes their characteristics such as electrical, magnetic, optical, mechanical, biological and so on. This phenomenon permits creation of novel functional materials with unique custom-made properties.

Development of completely new technologies and innovative nanomaterials and nanosystems with exceptional desirable functional properties lead to a new generation of products that will improve the quality of life and environment in the years to come. There are numerous new generation nanomaterial products of high quality including biocompatible biomaterials, antimicrobial biodevices, surgical tools, implants, decorative and optical devices, and, finally, nanocarriers and nanosystems.

One of the most important applications of the so called nanomedicine/nanotherapy appeared to be the targeting of medicines or additives to the desired organs and tissues using special nanoparticles and nanocapsules of various nature to cure human diseases. Because of their unique characteristics, nanosystems enhance the performance of medicines by improving their solubility and bioavailability, increasing their in vivo stability, creation of high local concentrations of bioactives in target cells and cellular compartments in order to gain therapeutic efficiency.

Nanocarrier systems used for medicine targeting are mainly consisting of lipid molecules, surfactants, and certain polymers, such as dendrimers, which are specially designed to be drug carriers. Hybrid organic/inorganic materials have also become popular now. Carbon-based nanostructures (nanotubes, etc.) are used for implant construction and as nanosystems for drug targeting. In our view, however, detailed toxicological studies are needed because of high chemical reactivity of carbon nanostructures as a result of their small size and high surface area.

Research efforts in such a complex area require interdisciplinary approach covering physics, chemistry, biology, material science and technology. This approach is realized in this volume at the highest degree. This book is the second one devoted to nanotherapy/nanomedicine and issued by Springer. It continues, and it is beneficially complemented to the previous Springer volume "Nanocarrier Technologies: Frontiers of Nanotherapy". Both of these volumes are edited by an internationally recognized scientist, Dr. M. Reza Mozafari. He succeeded to collect in each volume quality chapters authored by highly creative scientists from variety of countries throughout the World. The present volume starts with Dr. Nesrin Hasirci (Ankara, Turkey), an expert in biomaterial science and tissue bioengineering; Dr. Valentin Vlassov (Novosibirsk, Russian Federation), a famous specialist in antisense DNA-based medicines; Dr. Ali Azghani (Texas, USA) a world renowned biomedical scientist and Dr. Abdelwahab Omri (Ontario, Canada) expert in antibacterial and antioxidant delivery using archaeosomes. These follow by manuscripts from other world-class laboratories leaded by Dr. Ozlen Sahin, Dr. Jaspreet Singh, and Dr. M. Reza Mozafari. The book ends with chapters by Dr. Costas Demetzos (Athens, Greece), a famous specialist in dendrimers and liposomal anticancer delivery; and Dr. Yekta Ozer (Ankara, Turkey), an expert in radiopharmacy and nanocarrier targeting.

If the first volume, published last year, was devoted almost totally to the delivery systems of "nano-" scale, e.g., archaeosomes for medicine and vaccine delivery; solid lipid nanoparticles; hydrotropic nanocarriers; biomimetic approach to medicines' delivery; drug delivery using nanoemulsions; the use of new class of gemini surfactants and non-viral vectors for gene delivery; and dendrimers, the second one is of more general interest. It covers also new types of nanomaterials, which have outlooks as artificial implants and for variety of biomedical implications along with a description of traditional micro- and new nanocarrier systems and their release characteristics.

The role of nanomaterials and nanosystems for current pharmaceutical and biomedical research/technologies, and for our life is very hard to overestimate. We are sure that this volume, its outstanding contributions, creativity of the authors, and excellent editing as well will beneficially contribute to the field of biomedical nanotechnologies and nanotherapy.

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PREFACE

Nanotechnology has been defined as the scientific area, which deals with sizes and tolerances of 0.1 to 100 nm (Albert Franks). This is a working definition that refers to the properties of materials, in the above size range. More specifically, nanotechnology can produce, characterize and study devises and systems by controlling shape and size at nanometer scale. At that scale level, the chemical, physical and biological properties of the materials have fundamental differences in comparison to the material at the conventional scale level, because of the quantum mechanic interactions at atomic level.

During the last decade, research on nanoparticles properties has tremendously increased. In the European Union and in the USA a huge number of research projects on nano-devices are ongoing. Europe has already responded to challenges in the emerging field of Nanotechnology, participating with scientific experts from academia, research institutes and industry to the vision regarding future research and applications in Nanoscience.

Even though nanotechnology has become synonymous to innovation, there are challenges, which comprise issues of toxicity, long term stability and degradation pathways of nanoparticles, which may affect the environmental integrity and balance. The harmonization as well as the protection of the intellectual properties of the industries, which produce nanoparticles, is a concern of the regulatory authorities and experts. They have to identify issues incorporated into the existing regulatory framework or to evaluate new regulatory developments.

The economical landscape of nanobiotechnological products based on the definition that nanoscience includes system, devises and products for healthcare, aimed at prevention, diagnosis and therapy the total market segment for medical devices and drug / pharmaceuticals, represented in 2003 a value of 535 billion euros. The drugs segment values 390 billion euros. European Biotech companies have made great efforts mainly in drug development and medical devices, but commercialization effectiveness is relatively weak compared to the USA, with only half as many companies as in the United States.

These facts described above, concerning the scientific area of nanotechnology urge the need for studies and publications in order to characterize the impact of nanomaterials, nanotools and nanodevices in healthcare.

This volume edited by Dr. M. Reza Mozafari, presents important chapters, which refer to micro and nano systems, lipid vesicles and polypeptides as well as

applications of niosomes in the encapsulation and delivery of bioactive molecules by using different routes of administration.

It is well known that the design of new drug delivery systems which are able to transport toxic or poorly soluble bioactive molecules in aqueous media is driven by the need to improve drug effectiveness and to minimize side effects. Therefore, chapters concerning drug carriers are of great importance and useful for the readers of this volume.

Nasal and pulmonary routes for drug delivery depend on the type of nanoparticle such as liposomes, microspheres etc and the relevant chapter describes effectively the nasal and pulmonary drug delivery mechanism. It is worth noticing that inhalation, dermal and oral administration routes for preparing appropriate nanoparticles are of great importance.

The field of active implants has grown in recent years. Liposomal antibiotics, as coating for implants, are the subject of one of the chapters.

Cancer is known to be one of the main causes of death in the developed world. Nanotechnology through the use of drug delivery systems participates in the struggle against cancer. Liposomes are widely accepted as drug delivery systems. Particularly, nanoliposomes are considered as promising carriers especially in the case of bioactive agents, cosmetics and nutraceuticals. They can be studied by several techniques one of which is the Microscopy. This volume incorporates a chapter which deals with the study of liposomes by applying light and electron microscopy while in another chapter liposomes incorporated cytotoxic molecules have been tested against cancer cell lines and their uptake by the cancer cells was investigated.

Based on the aforementioned brief description of the contents of this volume, I conclude that the chapters are extremely important and the volume obviously covers a great range in the field of nanotechnology, gaining a great impact in the international literature. The Editor Dr. M. Reza Mozafari completed this effort successfully and the results should encourage him for relevant publishing efforts in the future. The excellent chapters that he gathered from high quality scientists contribute positively to the bibliography in the field of nanotechnology.

It is my honor to foreword this volume and I firmly believe that the prefix nano – derived from the Greek word '*νάνος*' which means something very small – will be the word of the 21st century.

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