

BOOK SERIES - 50th Year of Hacettepe University
Series Editor: Adil Denizli

NANOMATERIALS: FUNDAMENTALS AND APPLICATIONS

Sinan Akgöl
Editor



**HACETTEPE
UNIVERSITY**
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Kitapta yer alan yazı, resim ve şekil 5846 sayılı yasanın hükümlerine göre kısmen ya da tamamen basılamaz, dolaylı dahi olsa kullanılamaz, teksir, fotokopi ya da başka bir teknikle çoğaltılamaz. Her hakkı saklıdır, HACETTEPE ÜNİVERSİTESİ'ne aittir.

PREFACE

We have proudly celebrated the 50th anniversary of the foundation of Hacettepe University. We take pride in being one of the most successful universities in Turkey and being ranked among the leading universities in the World. Since the year 1967, when Hacettepe earned the status of ‘*University*’, it has never given up on its principle of continuously going ahead and reaching for the very best. Hacettepe, always preserving its values and basic principles, has become a pioneer university that has been intertwined with the society and pursued innovations, achieving many “firsts” ahead of others.

From medicine to biology, philosophy, statistics, physics and chemistry; from history of arts to the English, German and French languages; from sociology to engineering, fine arts and conservatory, Hacettepe University started almost 50 years ago developing interdisciplinary collaborations across a wide range of scientific fields, a research trend which has achieved a status of global recognition in the 21st century.

Hacettepe University, which was recognized as “*Research University*” by the decision of Council of Higher Education, dated September 26, 2017, has built a strong “brand” image over these 50 years with its qualified and unique contributions to science in Turkey and has been the country’s gateway to global scientific advances. It has graduated tens of thousands of students, each of whom has been our source of pride with their contributions to science, society and humanity as well as with their worldwide achievements. So have its graduates always been proud of Hacettepe.

Hacettepe University owes its success to its people who have always aimed to move forward by promoting interdisciplinarity and without giving up on the understanding “*To the leading edge... Toward being the best...*”

The Turkish and English series of books you are presented have been prepared in memory of the 50th anniversary of Hacettepe University by Prof. Dr. Adil Denizli, a distinguished researcher and faculty member who has heartily devoted himself to his university and science. Among the editors and authors of the book series are respected scientists from Hacettepe University, Turkey and abroad. The series covers the studies from the multi-/interdisciplinary research areas of sciences, mainly from Medicine, Science and Engineering Sciences, which particularly stand out among the World’s and Hacettepe’s research interests.

Readers benefiting from these books will certainly appreciate the value of the profound contributions Hacettepe University made to science both in the country and in the World each time they see the name of “*Hacettepe University*” in the context of the authors, editors, footnotes, citations and bibliographies. This work is an expression of respect for Hacettepe University and for those who have meticulously served in this university for 50 years with an interdisciplinary understanding.

Thank you Adil Denizli... I would like to express my sincere gratitude and thanks to all those who have contributed to this precious work.

I wish many 50 more years to go forward in line with our motto “*To the leading edge... Toward being the best...*”

Prof. Dr. A. Haluk ÖZEN
Rector

PREFACE

In 1954 “Hacettepe” was founded in two chambers of an old Ankara house as a Chair of Child Health, then in 1967 officially earned “university” status. Hacettepe University celebrated its 50th anniversary in 2017 by proud of rich heritage and the positive, life-changing impact globally through the strength of our research, teaching, innovation and enterprise. In just 50 years Hacettepe University has managed to forge a powerful global reputation as a strong research-led university. To celebrate 50th anniversary numerous standout events were planned and performed by proud of past and dreaming of the future.

The Hacettepe Book Series are published to honor the five decades of work not only for the field but also for society at large and to leave the scientific mark of Hacettepe University to the history.

Prof. Dr. Adil Denizli
Series Editor

PREFACE

Nanotechnology is a multidisciplinary branch of science which has several fields such as biomedical, pharmaceutical, agricultural, environmental, advanced materials and so on. Nanotechnologies involve designing and producing objects or structures at a very small scale, on the level of 100 nanometres (100 millionth of a millimetre) or less. Nanomaterials are one of the main products of nanotechnologies – as nano-scale beads, particles, tubes, rods, fibres, etc. In 2011, the European Commission released a specific recommendation on the definition of a nanomaterial (EC, 2011) which should be used in European Regulations, including REACH and CLP. According to this Recommendation, a “nanomaterial” means:

A natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50% or more of the particles in the number size distribution, one or more external dimensions is in the size range 1 nm–100 nm. In specific cases and where warranted by concerns for the environment, health, safety or competitiveness the number size distribution threshold of 50% may be replaced by a threshold between 1 and 50%. By derogation from the above, fullerenes, graphene flakes and single wall carbon nanotubes with one or more external dimensions below 1 nm should be considered as nanomaterials.

As nanotechnology develops, nanomaterials are finding uses in different application areas such as healthcare, electronics, cosmetics, textiles, information technology and environmental protection. The properties of nanomaterials are not always well-characterised, and they call for risk assessment of possible exposures arising during their manufacture and use.

This book consists of 10 chapters. The main properties of nanomaterials and characterization techniques are summarized in chapter 1. The different definitions of nanomaterials are provided to give an idea for synthesizing. The main classes of nanomaterials (quantum dots, carbon nanoparticles, silica, metal frameworks) and synthesizing of them are discussed briefly. The characterization techniques are summarized according to physicochemical properties of nanomaterials (particle size, structural and chemical properties). Physicochemical properties like particle size, shape, surface area, surface charge, and surface chemistry, hydrophilicity/ hydrophobicity collectively define the toxicity of nanoparticles. They can determine the fate of nanomaterials in biological systems. However, there is limited data about the toxicity of nanoparticles and their fate

in biological systems. Increased production and exposure to nanoparticles are likely to increase the possibilities of their adverse health effects. The understanding of the interaction between nanomaterials which can be taken into the body in every way and giving the right amount of exposure doses, make the application safe and effective. Because of this important subject, toxicity of nanomaterials was discussed in chapter 2.

In chapter 3, a brief history regarding discovery of Graphene was discussed along with brief explanations regarding its properties and synthesis methods. Although information given in this chapter does not include all there is to know regarding Graphene oxide based nanocomposites, a sufficient amount of information was discussed as an introduction to the world of Graphene oxide and related materials.

The unique self-assembly property of DNA enable researchers to design programmable 2D or 3D DNA nanostructures of desired shapes and patterns. Seeman and colleagues founded DNA nanotechnology in the early 1990s. Then, the field rapidly grew and DNA nanostructures were used in a wide variety of applications ranging from biosensors to imaging or drug/gene delivery. Chapter 4 mainly summarizes the major types and biological applications of DNA nanostructures. A brief summary for RNA nanostructures is also included.

Recently, nanotechnology has garnered significant interest, resulting in the development of nanotechnology-based applications of Antimicrobial peptides. In chapter 5, Antimicrobial peptides structural and functional properties and action mechanisms, nanotechnology based antimicrobial peptide formulations, nanoantibiotic delivery systems and future perspectives for nanotechnology-based applications of antimicrobial peptides were described.

A great deal of medical applications have been created over the last decades on nanomaterials. Medical application performances are affected by the method that depends on the chemical and physical technologies. These achievements lead to use nanomaterials as bio labeling, drug delivery, detection of proteins and DNA, DNA probes, tissue engineering, cancer detection, and Biomolecular sensors. Nanometer size also increases the sensitivity, selectivity and easy application characteristics. These parameters are crucial for the medical applications to reach maximum effect of application and minimizes malfunctions. The key parameter is modification of the nanomaterial by using specific materials such as antibodies, proteins, DNA, etc. In chapter 6 and 7, the authors describe the nanomaterials and give examples by demonstrating with schematic pictures how a nanomaterial is used in biomedical applications.

The potential risks of nanotechnology which offers a significant place in many applications to humans and ecosystems must be understood and researched. The biological activity and toxicity of nanomaterials depends on many factors such as size, surface chemistry and other surface properties. There are several ways of exposure to these materials via oral, dermal,

inhalation. When the nanoparticles enter the body, they can be distributed to various organs where they may remain structurally the same, become modified, or metabolized. Because of these important points, environmental and health effects of nanomaterials were discussed in chapter 8 by the authors.

Unique physicochemical properties of nanomaterials pave the way for novel applications in many industries. Although it is still in very early phase for plant science, nanomaterials serve inevitably important tools for agricultural applications to achieve secure, sustainable and high yielding crop production. Nanomaterials uptake, translocation and accumulation mechanisms and their impact on plant metabolism i.e. photosynthesis and development are subjects of intensive research activities of last few decades. Chapter 9 also presents an overview on plants and nanomaterials interaction in terms of phytotoxicity, and phytosynthesis of NMs by using plants.

Nano/micro sized motors can convert various energy sources to movement. Recent advances in nanotechnology have unbelievably enhanced the capability, versatility and functionality of nano/micro motors. These new abilities improve their applications in various applications like biomedical, environmental and sensor. In the final section, brief information about nano/micro motors is given. Detailed propulsion mechanisms are introduced along with the type of motors. Fabrication methods are also summarized and their diverse applications were briefly exemplified.

I feel honoured to have been the editor of this book, which was published to celebrate the 50 th anniversary of the establishment of Hacettepe University, where I received my PhD. I also thank specially to Prof. Dr. Adil Denizli for their kind invitation to organize this book. I am indebted to the scientists from various universities, who contributed greatly to the publication of this book. I hope *Nanomaterials: Fundamentals and Applications* will be helpful for both students and scientists working in the field of nanotechnology.

Prof. Dr. Sinan Akgöl
Editor

Nanomaterials: Fundamentals and Applications

Edited by Sinan Akgöl

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Sinan AKGÖL was born in İzmir in 1970. Having completed his primary and secondary education in İzmir. He studied Chemistry at Faculty of Science and Literature in Cumhuriyet University in 1996 and PhD from Hacettepe University in 2003. He became an Assistant Professor in 2004, an Associate Profesör in 2006 and Professor in 2013. He served as Vice Dean in Adnan Menderes University Faculty of Science and Literature from 2006 to 2009. He also served as Vice Dean in Ege University Faculty of Science between 2012 and 2016. He has been the Head of Biochemistry Department at Faculty of Science in Ege University since 2015. His academic achievements include writing chapters in 5 books, over 100 published articles journals indexed by SCI, more than 2000 citations, 18 articles in scientific journals, and 120 presentations of which 54 are international congress and 6 are invited talks. Sinan Akgöl is an active referee for various SCI indexed journals, and an editorial member of 4 journals. Additionally, in 2010 he created a research team called Biorege, where 12 MSc and 8 PhD students have graduated and 3 MSc and 6 PhD students are carrying out their post-graduate studies. He is married to Figen Akgöl, an English instructor at university, with one son, Rüzgar Ege Akgöl.

