Nanotechnology in the Life Sciences

Series Editor

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Nano and biotechnology are two of the 21st century's most promising technologies. Nanotechnology is demarcated as the design, development, and application of materials and devices whose least functional make up is on a nanometer scale (1 to 100 nm). Meanwhile, biotechnology deals with metabolic and other physiological developments of biological subjects including microorganisms. These microbial processes have opened up new opportunities to explore novel applications, for example, the biosynthesis of metal nanomaterials, with the implication that these two technologies (i.e., thus nanobiotechnology) can play a vital role in developing and executing many valuable tools in the study of life. Nanotechnology is very diverse, ranging from extensions of conventional device physics to completely new approaches based upon molecular self-assembly, from developing new materials with dimensions on the nanoscale, to investigating whether we can directly control matters on/in the atomic scale level. This idea entails its application to diverse fields of science such as plant biology, organic chemistry, agriculture, the food industry, and more.

Nanobiotechnology offers a wide range of uses in medicine, agriculture, and the environment. Many diseases that do not have cures today may be cured by nanotechnology in the future. Use of nanotechnology in medical therapeutics needs adequate evaluation of its risk and safety factors. Scientists who are against the use of nanotechnology also agree that advancement in nanotechnology should continue because this field promises great benefits, but testing should be carried out to ensure its safety in people. It is possible that nanomedicine in the future will play a crucial role in the treatment of human and plant diseases, and also in the enhancement of normal human physiology and plant systems, respectively. If everything proceeds as expected, nanobiotechnology will, one day, become an inevitable part of our everyday life and will help save many lives.

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Plant Nanobionics

Volume 2, Approaches in Nanoparticles, Biosynthesis, and Toxicity

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Foreword

The twentieth century has witnessed the exponential growth of world population demanding higher agricultural productivity to feed the increasing population. It is, therefore, required to use the modern technologies which can help agriculture to improve crop productivity as well as revenue. Nanotechnology is considered a perspective shifter which, by manipulating matter at atomic and/or molecular scale, enables us to develop new materials or devices that have unique properties beyond the realm of conventional ones. Among the several branches of nanotechnology, nanobiotechnology is believed to be one of the rapidly developing areas. As nanobiotechnology develops, focus is shifting towards farming that involves the use of nanomaterials to increase food quality, food quantity, plant protection, detection of plant diseases, monitoring plant growth, biosensors for monitoring soil quality, plant biosystems and reduce waste for "sustainable amplification." Hence, we must rethink the uses of nanobiotechnology approaches especially in plant nanobionics.

The present book *Plant Nanobionics: Approaches in Nanoparticles Biosynthesis and Toxicity* is a very timely publication, which intends to provide state-of-art information in the area of nanotechnology, broadly involving plant-based innovation and applications. The book comprises of 16 chapters. The first chapter by Sim et al. reviews on the carbon dots from green precursors with amplified photoluminescence: synthesis, characterization, and its applications in the bioimaging, sensing, photocatalysis, and biomedicine, while the second chapter presented by Lim et al. highlights the preparation, characterization, and application of perovskite oxides-based photocatalysts and applications in environmental remediation to energy conversion. In Chap. 3, García-Rosales et al. describe the use of biogenic material (pineapple peel) with iron nanoparticles for As(V) removal by sorption process. Chapter 4, discussed by R.P. Singh, highlights the biogenic plant-mediated synthesis of iron and iron oxide nanoparticles and their use in the treatment of cancer, drug delivery, MRI agents, catalysis, detection of toxicants/pollutants, and removal of pesticides from potable water. Also, in Chap. 5, he highlights the applications of eco-friendly biogenic copper and copper oxide-nanostructured materials as antimicrobial agent, cytotoxic activity against cancer cell lines, and several biomedical, pharmaceutical, and agricultural systems. Chapter 6 by Enamala et al. throws light

on recent advances in plant nanobionics where the engineered nanomaterials are combined with plant organelles with synthetic nanoparticles to enhance the function of plants and various applications. In Chap. 7, Marin-Bustamante et al. carry out an extensive review on the development of nanostructured materials applications in the design of edible films, functional polymers, and smart packaging for its use in the food sector industry. González-Reza et al. in Chap. 8 emphasize polymeric nanoparticles applications in food science. In Chap. 9, Rasool et al. highlight the applications as well as the role of nanomaterials in enhancing future crop production and protection. Djiwanti and Kaushik, in Chap. 10, discuss the promising nanoformulation procedures to be considered as future development of effective, efficient, and safe nanopesticide for plant protection. Hajong et al. describe the potential use of nanomaterials in crop protection for better eco-friendly management against biotic stresses in plants and agricultural practices in Chap. 11. Butnariu and Butu, in Chap. 12, present an overview of applications of nanobiosensors in plant biology. In Chap. 13, Peyravi et al. present an overview of toxicity of nanomaterials in plant and aquatic environments, especially carbon-based and metal/metal oxide nanomaterials. George et al. describe the use of nanocellulose (nanostructure composite material), which could be exploited to its advantage in polymer science as a promising reinforcement candidate due to its intrinsic chemical nature, aspect ratio, and degree of crystallinity, in Chap. 14. Rani et al. present the applications of different inorganic nanomaterials in the field of bioimaging techniques such as magnetic resonance imaging, X-ray computed tomography, positron emission tomography, ultrasound imaging, fluorescence imaging, and photoacoustic imaging in Chap. 15. Finally, Mufamadi and Mulaudzi, in Chap. 16, discuss the potential benefits of green engineered silver nanoparticles in plant protection, food quality, and economic impact for developing countries, especially sub-Saharan Africa.

Overall, it is a great effort by Dr. Ram Prasad as well as by experts from nine countries to make this book a highly resourceful, up-to-date, and worthwhile for the students, researchers, scientists, and academicians working in the field of plant and/or agriculture nanotechnology. I do hope that readers will find this book highly useful and interesting.

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Biography of Kamal Prasad

Kamal Prasad, Ph.D. is a Professor at the University Department of Physics and Director of Computer Centre, T.M. Bhagalpur University, Bhagalpur, India. He has 25 years of teaching experience in many organizations such as SLIET Longowal (Punjab), Central University of Jharkhand Ranchi, and Aryabhatta Knowledge University Patna – a technical university. Prof. Prasad has successfully guided 12 Ph.D. and 2 M.Tech. students and is working as the Associate Editor of *IET Nanodielectrics* and Editorial Board member of different journals including *Colloids and Surface B*. He has over 150 publications to his credit including 2 books, dozens of book chapters, and 15 X-ray diffraction reference data in JCPDS-ICDD, USA. His current research interests include synthesis and characterizations of eco-friendly ferroelectric/piezoelectric ceramics as well as ceramic-polymer composites and advanced nanomaterials for different industrial applications. He is an active peer of different internationally reckoned journals. He has delivered more than 30 invited lectures in different national and international conferences/workshops.

Preface

The purpose of this book is to describe the state of the art in research on smart nanoparticle synthesis from plants and toxicity effect on environment. This work on nanomaterials and nanotechnologies (herbicides, pesticides, sensors, and nanomaterials, among others) covers the main fields, like plant biology, agriculture, and technological improvements to increase crop yields, with special emphasis on sustainable management and the environmental impacts of nanopesticides.

I am confident that this book provides cutting-edge knowledge on both theoretical and applied features of green synthesis nanoparticles, characterization, formulation, application, and management, as well as the effects of nanoparticles on soil properties and plant characteristics, and some biotic interactions. This book is designed for undergraduate and postgraduate students, researchers, policy-makers, and other professionals in plant biology-/nanotechnology-related disciplines.

The use of plants to synthesize biogenic nanoparticles has been of great interest. Active ingredients in plants can change the oxidation state of metals, and these physiological processes have opened up new opportunities for us to explore novel applications, for example, the biosynthesis of metal nanomaterials. In contrast to chemical and physical methods, green approaches for synthesizing nanomaterials can be achieved in aqueous phase under gentle and environmental-friendly benign conditions. This approach has become an attractive focus in plant nanotechnology research toward resource-efficient and sustainable development. The book covers the synthesis of nanoparticles by plants and the mechanisms involved in such biosynthesis and a unique template for the synthesis of tailored nanoparticles targeted at therapeutics, medicine, agriculture, and biofuel and toward new applications that integrate biological system with nanomaterials to produce biohybrids and the next generation of bionic architectures.

This book should be immensely useful to nanobiotechnology, especially plant biologists, nanotechnologists, researchers, technocrats, and scientists of plant biology and agriculture. I am honored that the leading scientists who have extensive, in-depth experience and expertise in plant systems and nanobiotechnology took the time and effort to develop these outstanding chapters. Each chapter is written by internationally renowned researchers/scientists, so the reader is given

an up-to-date and detailed account of our knowledge of the nanobiotechnology and innumerable applications of plant biology.

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Ram Prasad, PhD is associated with Amity Institute of Microbial Technology, Amity University, Uttar Pradesh, India, since 2005. His research interests include applied microbiology, plant-microbe interactions, sustainable agriculture, and nanobiotechnology. He has more than one hundred fifty publications to his credit, including research papers, review articles, and book chapters and five patents issued or pending, and edited or authored several books. He has 12 years of teaching experience and has been awarded the Young Scientist Award (2007) and Prof. J.S. Datta Munshi Gold Medal (2009) by the International Society for Ecological Communications; FSAB Fellowship (2010) by the Society for Applied Biotechnology; the American Cancer Society UICC International Fellowship for Beginning Investigators, USA (2014); Outstanding Scientist Award (2015) in the field of Microbiology by Venus International Foundation; BRICPL Science Investigator Award (ICAABT-2017); and Research Excellence Award (2018). He serves as Editorial Board Member of *Frontiers in Microbiology*, *Frontiers in Nutrition*, and *Academia Journal of Biotechnology* and as Series Editor of Nanotechnology in the Life Sciences, Springer Nature, USA. Previously, Dr. Prasad served as Visiting Assistant Professor, Whiting School of Engineering, Department of Mechanical Engineering, at Johns Hopkins University, USA, and, presently is working as Research Associate Professor at the School of Environmental Sciences and Engineering, Sun Yat-Sen University, Guangzhou, China.