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Nanotechnology – An Emerging Technology for Use in Agricultural and Food Research

C. Karunakaran

Post-Doctoral Fellow, Department of Biosystems Engineering, University of Manitoba, Winnipeg, MB, Canada R3T 5V6

D.S. Jayas

Associate Vice-President, Distinguished Professor, and Canada Research Chair in Stored-Grain Ecosystems, University of Manitoba, Winnipeg, MB, Canada R3T 2N2

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Abstract

Nanotechnology, the science of building atomic, molecular or macro-molecular sized materials, devices, structures or systems is finding applications in different fields. The technology is presently utilized by the chemical, health care, biotech, and manufacturing industries. In the pharmaceuticals, drugs with nano-sized particles are highly efficient with minimal side effects. Micro-scale mechanical and electro mechanical devices are determined to be highly sensitive, durable, and less expensive. Nanotechnology has potential applications in agricultural and food engineering such as exploring biological life processes, monitoring plant and animal health, analyzing and determining product qualities, developing novel materials from agricultural products, and reducing environmental pollutions. This short article reviews the present applications of nanotechnology in other industries and explores its potential applications in agricultural and food industries.

INTRODUCTION

Nanotechnology is the science of developing very small materials, devices, structures, and systems at the atomic, molecular, or macromolecular level. It is also called "molecular manufacturing". The size of nanomaterials and devices are generally in the range of 1 to 100 nm (10^{-9} to 10^{-7} m) (Anonymous 2005). For instance, some of the nanodevices and materials have a size of one in 10,000th of the width of a human hair. Micro devices, micro-electromechanical systems (MEMS), microarrays, and micro analytic systems are being developed and utilized presently (Hilt and Byrne 2004). The advancement of nanotechnology is fostered with the availability of techniques to examine and visualize things at the atomic scales using scanning electron microscopy (SEM) and atomic force microscopy (AFM) techniques.

The objective of this short paper is to highlight the present applications of nanotechnology and its future potential applications in the filed of agricultural and food engineering.

APPLICATIONS OF NANOTECHNOLOGY

Nanotechnology is presently used in medicine, mechanical engineering, and computing science. Its use is demonstrated by elaborating its application in medical science.

In medical science, the development of nanoscience and technology has had a profound effect on cellular and tissue engineering, diagnostics, and therapeutics (Hilt and Byrne 2004). In tissue engineering, nanotechnology helps in the development of biological tissues and materials based on physiochemical and mechanical properties of cellular components for tissue or organ implants and for drug testing. In diagnostics systems, the development of miniature-sized-testing devices enhance the speed, precision, and early detection of diseases. The testing devices are highly sensitive, minimize disease diagnostic time, and require small sample and chemical reagents. In therapeutics, the technology has enabled to deliver drugs to specific regions or tissues in a controlled manner. The target drug delivery system is enhanced by the development of nanoscale devices in the form of capsules, pumps or valves to regulate the delivery of drugs based on the condition of the tissues over a period of time. The method is called as smart treatment system as the drug release is controllable using microchips. The smart treatment system is highly efficient and minimizes the drug dosage and side effects. For instance, microneedles have been demonstrated to penetrate the artery walls in rabbits for target drug delivery.

NANOTECHNOLOGY IN AGRICULTURAL AND FOOD ENGINEERING

The potential applications of nanotechnology in agricultural and food engineering are envisioned in the following areas: (i) Molecular and cellular biology; (ii) Nanobiotechnology; (iii) BioMEMS; and (iv) Nanobioprocessing.

Molecular and cellular biology

Nanotechnology facilitates good understanding on the cellular level of biological mechanisms and thus helps to explore novel applications of biological systems. It helps to develop tools and devices to explore the cell biology. Developing tools and devices to understand the nature, behaviour, and interactions of biological cells and molecules will open up new opportunities in animal- and plant-reproductive science, disease diagnostics and prevention, and agricultural waste treatments and utilization.

Nanobiotechnology

Nanobiomaterials are developed utilizing DNA molecules as the basic building units using nucleic acid engineering. The DNA molecules can be modified to develop novel biomaterials such as nanowires and nanomembranes that can be used for nanofiltration processes (Hoek and Jawor 2004)

BioMEMS

The use of MEMS (micro-electro mechanical systems) can be extended for biological applications by combining the MEMS technology with biological sensors. The development of sensors at the nanoscale helps to detect traces of chemical and biological contaminants from samples utilizing biological processes. The sensors will have wide applications in drug delivery systems in plants and animals. The use of these sensors will enhance agricultural production and can be used for rapid detection of pathogens and contaminants during agricultural production and processing and from the environment. They can be used to monitor the shelf life of agricultural and food products.

The biosensors at the nanoscale help to implant them in animals and plants. They can in turn help to detect diseases causing pathogens before the symptoms appear externally and affect the entire herds of animals or plants in a field. It has a potential application to determine environment air and water characteristics and to reduce pollution problems.

Smart Treatment systems

This method utilizes MEMS systems to carry the molecular coded drugs to deliver the drugs to the infection site. These systems are designed to be site specific based on chemical analysis. The smart treatment delivery systems have applications in plant and animal science to minimize the use of unwanted nutrient application, growth regulators, pesticides, and antibiotics. They in turn increase the efficiency of the systems as the delivery systems can be regulated to deliver nutrients and chemicals where and when they are needed.

Nanobioprocessing

Bioprocessing is used in agricultural and food engineering to create desired materials utilizing the biological materials and processes. The nanotechnology offer devices and mechanism by which the bioprocessing can be monitored to increase the efficiency of bioprocessing and to enhance the quality of end products. The functional behaviour of microbial organisms under different conditions and their interactions with the environments can be determined using cellular and molecular studies. The results will help to enhance bioprocessing of agricultural and food materials and to effectively use microbes for removal of contaminants from soil, water, and air (Kretschmer and Chianelli 2004).

CONCLUSION

Nanotechnology is the science of developing novel materials and devices at the nanoscale. It has been widely used in medical science. It has potential for diverse applications in agricultural and food engineering that needs to be studied extensively through research.

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