Chapter 68
The Impact of Nanotechnology on Environment

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ABSTRACT

Nanotechnology is an emerging field that covers a wide range of technologies which are presently under development in nanoscale. It plays a major role in the development of innovative methods to produce new products, to substitute existing production equipment and to reformulate new materials and chemicals with improved performance resulting in less consumption of energy and materials and reduced harm to the environment as well as environmental remediation. The environmental impact of nanotechnology is the possible effects that the use of nanotechnological materials and devices will have on the environment. This impact can be split into two aspects: the potential for nanotechnological innovations to help improve the environment (beneficial part), and the possibly novel type of pollution that nanotechnological materials might cause if released into the environment (harmful part). The nanoparticles can be used an individual product in pure form or as an adjuvant with existing products in order enhance their activities. The beneficial aspects of nanoparticles include water filtration and treatment, green energy synthesis, degradation of plastics, detoxification harmful dyes and chemicals. The harmful aspects consist of unwanted by-products of nanoparticles, effluents of nano industries, etc.

INTRODUCTION

The 20th and 21st centuries are commonly defined by unrelenting quest for the provision of goods and services to meet human needs, improve their quality of life and create wealth. Such quest has caused rapid industrialization, urbanization, extensive agriculture, high energy demand (e.g. evidenced via over-reliance in burning fossils for transportation, domestic and industrial purposes), and rigorous exploitation

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of natural resources (e.g. destruction of rainforests, drying of water resource systems). Unfortunately, such actions resulted in causing unintended outcomes like high population growth, rapid increase in hazardous waste generation, extensive pollution of environmental systems, causation of climate change-inducing effects, and extinction of certain ecological species. To counter these undesirable impacts, the promises are forced to modify their production mechanism which suits for the environment and climate protection. The awareness given by those problems laid a path for the development of numerous science- and technology-driven solutions namely sustainable development (SD), design for environment (DFE), end-of-pipe treatment, and pollution prevention (PP) and etc. The nanotechnology is a branch of science which emerges recently, but has the effective alternative approaches to overcome these above mentioned problems.

Nanotechnology is the scientific study of specific nanomaterials. The nanomaterials are typically defined as materials smaller than 100 nm in at least one dimension. At this scale, the materials often possess novel size-dependent properties which are different from their large counterparts. The nanomaterials exhibit special physical and chemical properties that make them interesting for novel, environmentally friendly products. For example, the increasing of durability in materials against mechanical stress or weathering will helps in increasing the life time of products. The nanotechnology based dirt and water resistant coatings have drastically reduced the cleaning effects. Further the addition of nanoparticles to an alloy will decrease the materials weight and helps in conserving energy during transportation. In chemical industries the nanoparticles are used based on their special catalytic properties. They can replace environmentally problematic chemical catalysts in certain applications. In recent days it is highly believed that the nanotechnology based products and processes will play a major role in climate protection and solves most our environmental problems. The following chapters will provide the basic information about the impact of nanotechnology on environment.

Nanotechnology (“nanotech”) is the manipulation of matter on an atomic, molecular, and supramolecular scale. The earliest, widespread description of nanotechnology referred to the particular technological goal of precisely manipulating atoms and molecules for fabrication of macroscale products, also now referred to as molecular nanotechnology. A more generalized description of nanotechnology was subsequently established by the National Nanotechnology Initiative, which defines nanotechnology as the manipulation of matter with at least one dimension sized from 1 to 100 nanometers. This definition reflects the fact that quantum mechanical effects are important at this quantum-realm scale, and so the definition shifted from a particular technological goal to a research category inclusive of all types of research and technologies that deal with the special properties of matter that occur below the given size threshold. It is therefore common to see the plural form “nanotechnologies” as well as “nanoscale technologies” to refer to the broad range of research and applications whose common trait is size. Because of the variety of potential applications (including industrial and military), governments have invested billions of dollars in nanotechnology research. Until 2012, through its National Nanotechnology Initiative, the USA has invested 3.7 billion dollars; the European Union has invested 1.2 billion and Japan 750 million dollars (Gaffet et al., 1996)

Nanotechnology as defined by size is naturally very broad, including fields of science as diverse as surface science, organic chemistry, molecular biology, semiconductor physics, microfabrication, etc. (Ahmad et al., 2002). The associated research and applications are equally 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 direct control of matter on the atomic scale.