Chapter 3
Nanobiotechnology and Therapeutics

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ABSTRACT

Nanobiotechnology deals with the application of the tools and processes of nanotechnology to build devices for studying and manipulating biological systems. Current approaches of diagnosis and treatment of various diseases, especially cancer have major limitations such as poor sensitivity or specificity and drug toxicities respectively. Novel and improved methods of cancer detection based on nanoparticles are required to be developed. Some of the nanoparticles used for diagnostic purposes are paramagnetic nanoparticles, quantum dots, nanoshells and nanosomes. Drugs with high toxic potential like cancer chemotherapeutic drugs can be given with a better safety profile with the utility of nanotechnology. These can be made to act specifically at the target tissue by active as well as passive means. Simultaneously, other alternative ways of therapy such as heat induced killings of cancer cells by nanoshells and gene therapy are also being developed. Thus, it indicates that nanomedicine in future would play a crucial role in the treatment of human diseases.

INTRODUCTION

Nanotechnology deals with the study about producing and manipulating materials at the nanometer scale size. Nanometer is one-billionth of a meter or10^{-9}meters and is abbreviated as "nm." Things at the level of nano size such as a red blood cell (size varies between 6000-10000 nm in diameter), a ribosome is approximately (30 nm long) and moreover, the width of a DNA molecule is (about 3 nm) can be studied. Thus, nanobiotechnology can be briefly defined as biotechnology which involves the application of the tools and processes of nanotechnology to study and manipulate biological systems.

It is a highly interdisciplinary field of material science which involves the concepts and applications of chemistry, physics, biology and engineering. In order to address new problems and find out the innovative solutions such as new implant coatings which were originally developed to improve the wear resistance of tools is now used as a biocompatible coating on stents. Likewise, many other products have

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been developed and currently available on a commercial basis including the enabling of drug delivery and improvement of biocompatibility (Wieneke et al., 2002a; 2002b).

An important aspect of nanobiotechnology is to characterize materials at the nanoscale level. This step involves analyzing the structure and properties of the materials in order to understand how the materials can be made functional for various applications. Characterization is important step for the fundamental understanding of materials as well as improvement in the quality of manufactured goods. Since, nanoscale structures are too small, the use of specialized tools such as scanning probe microscopes, atomic force microscopes and helium-ion microscopes are inevitable and each tool has its own advantages and disadvantages.

Significantly, nanobiotechnology might be involved in therapeutical fields, both for the diagnosis as well as treatment of diseases. For example, tumor cells and the blood vessels that supply them are abnormal in several ways that tend to accumulate small particles, while healthy cells do not. This is called the enhanced permeability and retention effect. This technique is being assessed in clinical trials by using gold nanoshells. These nanoshells are tiny balls of silica surrounded by a thin shell of gold. Further, these nanoshells also can be coated with molecules specifically designed to stick to tumor cell markers or antigens. Once the gold nanoshells are accumulated in the tumor tissue, they can be heated with lasers to kill the tumor cells while having little effect on healthy tissue.

This chapter mainly deals with the aims to understand the basic concepts on which nanobiotechnology is based and also to explore the applications of these emerging technologies in the field of therapeutics.

Basic Science of Nanobiotechnology

It is known that every matter is composed of atoms and molecules with physical and chemical properties. These properties are determined by the type and arrangement of atoms and molecules in the matter;

1. Physical properties can be measured without changing the composition of the material. The boiling and freezing temperatures of water are physical properties and these temperatures can be measured without changing the water into a different chemical forms.
2. Chemical properties refer to know that how one material can interact with any other material. Many of the chemical and physical properties of water are determined by its polar structure. In water, oxygen has a slight negative charge, while two hydrogen ends are slightly positive charge. This polar structure gives water many special properties like the ability to dissolve many other substances.

Though materials composed of the same atoms and molecules but may show different properties depending on their arrangements at the nanoscale levels and also on many other factors that can influence these properties. For example, snowflakes structures are a type of ice formation whose nearly infinite variety of individual shapes can be categorized as needles, hollow columns, prisms or plates. Although, each water molecule is the same, however, the many individual shapes are formed by nanoscale interactions of the water molecules as the snowflake forms.

In the case of snowflakes, the chemical structure of the water molecules remains the same, even though different flake shapes are formed while on other hand, materials may have the same chemical formula but show a different chemical bonding structure. For example, differences between graphite, diamonds and carbon nanotubes can be considered here. All are composed mainly of carbon atoms but