Chapter 35
Applications of Gold Nanoparticles in Cancer

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ABSTRACT

This chapter deals with the applications of gold nanoparticle in cancer and various strategies to target cancer cells by using gold nanoparticles. They are in great demand for biomedical applications such as DNA/Protein detection, bimolecular regulators, cell imaging and cancer cell diagnostics. The ability to tune the surface of the particle provides access to cell –specific targeting and controlled drug release. Depending on their size, shape, degree of aggregation, and local environment, gold nanoparticles can appear red, blue, or other colors. The novel drug delivery systems offer the opportunity to improve poor solubility, limited stability, bio distribution, and pharmacokinetics of drug as well as offering the potential ability to target specific tissues and cell types. The multifunctional gold nanoparticles are attractive organic –inorganic hybrid material composed of an inorganic metallic gold core surrounded by an organic or bimolecular monolayer they provide desirable attributes for the creation of drug delivery in cancer.

INTRODUCTION

Nanotechnology is an interdisciplinary research field involving chemistry, engineering, biology, and medicine. The term nano originates from the greek word "nanos" which means dwarf or small. When nano is used as a prefix it means one billionth part of (10^{-9}). In nanotechnology, nano refers to things in the range of 1–100 nanometers in size. Atoms are less than one nm in size; molecules and cells vary in size from one to several nanometers. Currently metal-based Nano conjugates are used in various biomedical applications such as probes for electron microscopy to visualize cellular components, drug

DOI: 10.4018/978-1-5225-3158-6.ch035

delivery (vehicle for delivering drugs, proteins, peptides, plasmids, DNAs, etc.), detection, diagnosis and therapy (targeted and non-targeted). However, biological properties of bare-metal nanoparticles have remained largely unexplored. Nanoparticles are typically smaller than several hundred nanometers in size, comparable to large biological molecules such as enzymes, receptors, and antibodies. With the size of about one hundred to ten thousand times smaller than human cells, these nanoparticles can offer unprecedented interactions with biomolecules both on the surface of and inside the cells, which may revolutionize cancer diagnosis and treatment.

Various classes of nanoparticles have been developed as drug carriers, including organic ones (e.g. polymers, dendrimers, and solid lipid), inorganic ones (e.g. magnetic iron oxide, quantum dots of various mineral compositions, silver, gold, and silica), and protein based ones (e.g. viruses and albumin) (Husseini, 2008; Faraji, 2009; Veiseh, 2010). In recent years, the use of nanoparticles, particularly metal nanoparticles have been expanded in biomedical research. They are used in diagnosis and therapeutics due to their unique properties of small size, large surface area to volume ratio, high reactivity to the living cells, stability over high temperatures and translocation into the cells, etc. They are available in different sizes and shapes due to their ability to react and agglomerate with other nanoparticles in their surroundings. Among these, gold being inert and relatively less cytotoxic is extensively used for various applications including drug and gene delivery (Ghosh, 2008; Pissuwan, 2009). However, due to their "nano" size, their entry is easily facilitated into various cells posing one of the greatest difficulties in using these nanoparticles for targeted delivery to specific tissues. To obviate this problem, researchers have been conjugating these nanoparticles with various biomolecules and ligands to develop strategies for targeted delivery. Gold nanoparticles enjoy both the enhanced permeability and retention (EPR) effect (Ghosh et al., 2008).

GOLD NANOPARTICLES

Gold Nanoparticles (AuNPs) are known for their unique optical and electronic properties. They produce vibrant colors upon interaction with visible light and thus were used by artisans in the past centuries. Gold nanoparticles have proved to be versatile for a range of applications with well characterized physical and electronic properties. Moreover, their surface chemistry can be easily modified. Their large surface area to volume ratio enables surface coating with a variety of molecules including therapeutics and target agents. Over the past few decades, inorganic nanoparticles, whose structures exhibit significantly novel and distinct physical, chemical, and biological properties, and functionality due to their nanoscale size, have elicited much interest.

AuNPs have attracted a great deal of attention due to their chemical inertness and biocompatibility, making them suitable for biomedical applications such as the treatment of cancer and gene and drug delivery systems (Everts et al., 2006; Paciotti et al., 2006). Chemical, physical and biological methods have been employed for the synthesis of AuNPs, among which the chemical method is widely used due to its ease in process control, high yield and rapid throughput (Green et al., 1998; Ackerson et al., 2010; Biswal et al., 2011). However, the chemical synthesis of NPs often requires the use of toxic reagents such as reducing and stabilizing substances. Hence, biological synthesis of AuNPs has been suggested as an ecofriendly alternative to chemical and physical methods (Mohanpuria et al., 2008). Biological