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Gold Nanosol: An Optically Active Nanotool for Disease Detection and Therapy

Nitai Debnath and Sumistha Das*

Amity Institute of Biotechnology, Amity University Haryana, India

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***Corresponding author:** Sumistha Das, Amity Institute of Biotechnology, Amity University Haryana, India, Email: sumistha.das@gmail.com

Abstract

Metal nanostructures are of immense scientific interest in respect to their bulk counterparts because of their surface polaritons which are enable of generating strong enhancement of electromagnetic field making them to be useful for diverse research fields of biophysical and biomedical applications for detection, sensing and imaging tiny biological entities in living or non-living state. It has not only paved a simpler technique to invade safely but also facilitated therapeutic potential of a drug by acting as effective carrier material with ability to be tracked due to unique optoelectronic feature. In this short note we wanted to summarize the immense potential of very easily producible optically active gold nanosol for their broad application in disease detection and therapeutic application.

Introduction

The Greek word "nanos" refers to dwarf is the origin of the terminology of nanoscience. The science is not new as Nanoparticles (NPs) have long been used in ancient human civilizations in pottery and medicines. The technology dates back to 1st millennium BC, when red colloidal gold was used in Indian ayurveda (the most ancient medicine system globally) as "Swarna Bhasma" and "Makaradhwaja"[1]. There is a strong history of using colloidal gold in aqueous condition to have therapeutic potential agaist large number of diverse disease situations [2]. Richard [3] Feynman, visionary scientist in the field of nanoscience and nanotechnology expressed his view on the very novel properties and applicabilities of proposed technology in 1959 in his lecture "there is plenty of room at the bottom" at California Institute of Technology (Caltech) on the annual gathering of the American Physical Society [4]. Norio Taniguchi coined the term 'nanotechnology' [5] and later the idea was first vividly elucidated by Drexler [6] in the 1980s. The past decade was instrumental enough for dramatic improvisation of nanoscience and nanotechnogy and their very fascinating qualities of size dependent magnetic, opto-electronic and quantum mechanical properties attracted scientists globally for amalgamation of ideas from the field of health and medicine [7].

From the early 1990's, extensive research throughout the world has led to the development of innumerable types of nanomaterials [8-9]. Widespread repositories of NPs have already been constructed based on their different sizes, shapes, and materials, and with a wide variety of chemical and surface properties. Metal NPs are of broad spectrum interest because of their unique application potential in catalysis, single electron tunneling, non linear optical devices and DNA sequencing etc. Amongst them gold NPs (GNPs) are of central importance because of their broad chemical versatility, easy synthesis, capability of minute quantity of GNPs to reach the target site for biomedical applications.

There are a huge number of chemical synthesis procedures for GNP production [10]. Green synthesis is also now being widely researched as a biological method of GNP formation. Here during synthesis, optimum and non-hazardous solvent choice, reducing agent of environmentally safe nature and biocompatible surface stabilizing material are three main factors been prioritized [11]. Phytochemicals such as tea extract is recently being used in synthesis of GNPs and silver Nanoparticles (AgNPs). Aloe vera (*Aloe Barbadensis*) and lemongrass (*Cymbopogon flexuosus*) extract are also popular constituents in synthesis of triangular-shaped GNPs and spherical-shape AgNPs [12-16]. Mukherjee et al. [17-18] introduced the synthesis of extra cellular and intracellular silver and GNPs using live microorganisms (*Verticillium, Fusarium oxysporum*), another breakthrough example biological green synthesis.

Moreover, surfaces of these particles can easily be modified with thiol/ amine containing molecules [19]. Hence GNPs are widely engineered as nano platforms for disease detection using imaging and self-assembly and target specific delivery of drugs outpacing various immunological, cellular, and biophysical barriers. Recent studies with GNPs revealed its potential possibilities in healing cancer, and also as intravenous contrast enhancers in medical imaging [20-21].

The electronic amalgamation of localized surface Plasmons along with propagating polaritons on the SPR gold and apparent enhancement in the mass of analytes immobilized on highly dense and heavy molecular weight GNPs are two key features for huge signal amplification properties of GNPs for bioimaging and sensing applications. In this scenario photo sensitive methods for early detection of single nucleotide polymorphisms (SNPs) in genomic DNA using GNP-enhanced surface plasmon resonance imaging (SPRI) is been of research interest for rapid improvement in highly sensitive and quick reporting of very trace amount of bio-molecules. Biocompatible polymeric matrix Chitosan and poly (p-aminobenzene sulfonic acid) coupled with GNPs are being used as an excellent platform for fabricating novel biosensors. For example, a nanoplatform composed of carboxymethyl chitosan and GNPs for H_2O_2 has already been reported for bioelectrochemical sensing [22]. Similarly, a sandwich-type complex developed by Li and his co-workers is a combination of oligodeoxynucleotide (ODN) backbone immobilized on a QCM electrode, a target DNA and a GNP modified DNA, for more rapid and advanced detection.

In India, there is a long heritage of using minute quantities of colloidal gold and silver as medicinal doses [23]. Aurafonin® and Tauredon®, gold based anti-inflammatory agents have been widely used as remedial for rheumatoid arthritis [24]. Recent studies with GNPs revealed its potential possibilities in healing cancer. On irradiation with focused laser pulses of suitable wavelength, GNPs can kill cancer cells [25]. Moreover, GNP based drug carriers [26] and intravenous contrast enhancers in medical imaging [27-28] are also being extensively researched.

Target specific celluar and intracellular biodistribution of GNP's [29], as siRNA vehicle in RNAi technology [30], macrophage and proinflammatory cytokine elicitation [31-32], antibody mediated immunoassays treatment and diagnosis [33] etc is also very significantly been studied through last two decades with GNPs. Mirkin's group has pioneered the technology of oligonucleotides (DNA,RNA) and protein conjugated optically active GNPs for a number of applications in nano bio imaging and sensing based detection techniques [34-36]. Photothermal ablation a novel therapeutic approach for killing abnormal cells target specifically by using heated GNPs generated through irradiation with light source of appropriate wavelength, after which heated NPs dissipate heat to its immediate environment, the phenomenon is called hyperthermia is very popular approach for cancer therapy. Advantage of hyperthermia along with targeted delivery approach is now being utilized for selective killing of cancerous cells both *in vitro* and *in vivo*, either directly by heating or by localized release of anti cancerous molecules trapped in hydrogels [37].

Nanotechnology as a ground breaking technology is recently being utilized in energy generation and storage, electrical devices, societal issues relevant to natural resources like drinking water, agricultural fields as fertilizers, clinical applications, as well as biocatalyst and also as antimicrobial coatings which is associated with increased production, processing and handling of NPs. So concerns are being developed about their potential risks to health and environment. Extensive organ specific GNP-biointeraction studies are to be considered for their successful implication in different biomedical applications.

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