

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



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Mini Review

The term nanotechnology is derived from 'Nanos' which is the Greek word for dwarf. 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 as "Swarna Bhasma" and "Makaradhwaja" in Ayurveda the traditional medicine system in India [1]. In 16th Century Europe an aqueous form of colloidal gold called "Aurum Potabile (drinkable gold)" was considered to have therapeutic effect in a number of diseases [2]. Richard P. Feynman, often referred as father of the field of NP research [3] presented his brilliant foresight and visionary thought about the properties of NPs and their future implications in 1959 in his lecture "there is plenty of room at the bottom" at California Institute of Technology (Caltech) during Annual meeting of the American Physical Society [4]. The term 'nanotechnology' was defined by Norio Taniguchi [5] and later the idea was first vividly elucidated by K. Eric Drexler [6] in the 1980s. However, in the past 10 years, dramatic improvisation in the field of nanoscience and nanotechnology and the very fascinating qualities of size dependent optical, electronic, magnetic, and mechanical properties of NPs have engaged the attention of researchers from almost all branches of science including biology 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 have received considerable attention due to their potential applications in catalysis, single electron tunneling, non linear optical devices and DNA sequencing etc. Amongst them gold NPs (GNPs) are of immense 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 three main factors are mainly considered: solvent choice, the use of an environmentally benign reducing agent, and the use of a non-toxic material for NP stabilization [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 another novel biological method for the synthesis of extra cellular and intracellular silver and GNPs using live microorganisms (Verticillium, Fusarium oxysporum). Moreover, surfaces of these particles can easily be modified with thiol/ amine containing molecules [19]. Hence GNPs are widely engineered as nano platforms for effective and targeted delivery of drugs overcoming many biological, biophysical, and biomedical barriers. Recent studies with GNPs revealed its potential possibilities in healing cancer, and also as intravenous contrast enhancers in medical imaging [20,21].

The signal amplification mechanism of GNPs can be generally summarized into two points:

- (i) the electronic coupling between the localized surface plasmon of GNPs and the propagating Plasmon on the SPR gold surface and
- (ii) The high density and high molecular weight of GNPs increase the apparent mass of the analytes immobilized on them.

In this light sensitive methods for the analysis of single nucleotide polymorphisms (SNPs) in genomic DNA using GNP-enhanced surface Plasmon resonance imaging (SPRI) is been research interest for advancement in disease detection and bio-imaging. The nanocomposite of GNPs and biopolymer, such as chitosan and poly (p-amino benzene sulfonic acid) has been employed as an excellent matrix for fabricating novel biosensors. For instance, Xu and co-workers reported a nanocomposite composed of carboxymethyl chitosan and GNPs for H2O2 bio-electrochemical sensing [22]. Li and his co-workers developed

a sandwich-type complex consisting of an oligodeoxynucleotide (ODN) immobilized on a QCM electrode, a target DNA and a GNP modified DNA, in which the latter two oligonucleotides were both complementary to the ODN.

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. Application of GNP's in cellular and intracellular targeting and bio-distribution [29], siRNA carrier in RNAi technology [30], macrophage and pro-inflammatory cytokine elicitation [31,32], antibody mediated immunoassays treatment and diagnosis [33] etc. is also very significantly been studied through last two decades. Mirkin's group has developed a number of applications of SPR properties of GNP conjugated with oligo-nucleotides for detection of DNA, RNA and proteins [34-36]. Under excitation with a suitable light source, GNPs get heated up and dissipate heat to its immediate environment, the phenomenon is called hyperthermia. 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 cross cutting technology is recently being utilized in energy generation and storage, electrical devices, societal problems related to natural resources, drinking water, agricultural fields as fertilizers, clinical applications, as catalysts and as antimicrobial coatings -thus is accompanied with larger production, handling and processing of NPs. So concerns are being developed about their potential risks to health and environment. Extensive organ specific GNP-bio interaction studies are to be considered for their successful implication in different biomedical applications.

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