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LIPOSOMAL GOLD AND SILVER NANOPARTICLES

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Abstract - Liposomes can be described as artificially made vesicles composed of one or more phospholipid bilayer(s). They are being used to encapsulate different material including medicinal and nutritional compounds as well as cosmetic and diagnostic agents. Recently, liposomes have also been employed for the entrapment and delivery of a number of different trace elements (e.g. selenium), divalent cations (such as calcium and magnesium) and metal nanoparticles. Because of their unique optical and physical properties, silver and gold nanoparticles are widely used in many fields as ideal materials for labelling, imaging, and sensing. This review article addresses the use of liposome-encapsulated silver and gold nanoparticles in targeting drugs and diagnostic agents with reduced cytotoxic effects in patients with various cancers and many other diseases.
Index Terms – Cancer, diagnosis, encapsulation, gold nanoparticle, liposome, nanosilver, selenium.

1. INTRODUCTION

Nanotechnology involves design, characterization, manufacture and application of structures, devices and systems by controlling shape and scale at nanometric scale. Applications of nanotechnology in the treatment, diagnosis, monitoring and control of biological systems is the scope of nanomedicine and nanotherapy [1]. There are different types of nanoparticles suitable for applications in encapsulation, controlled release, drug delivery, gene therapy, food, nutrition and cosmetics. These nanosystems can be categorized as nanoliposomes, quantum dots, polymeric nanoparticles, solid lipid nanoparticles, nanocrystals, dendrimers, fullerenes, inorganic nanoparticles (e.g. gold and magnetic nanoparticles) and the recently introduced tocosomes [2-5]. Intracellular drug delivery can be achieved via different mechanisms such as fusion, endocytosis, diffusion and through ion channels or transport proteins. Advantages of the encapsulated formulations over conventional un-encapsulated therapeutics are enhanced solubility of the drug, reduction in the quantity of doses given to the patient, protection of the drug molecules from degradation and inactivation, increased bioavailability, decreased elimination and precise drug targeting. Particularly, liposomes and nanoliposomes (also known as lipid vesicles) have been proven successful in drug encapsulation and targeting [6-8]. In recent years, much advancement was made in the biomedical applications of lipid vesicles especially in disease diagnosis and therapeutics due to improved biocompatibility and stability. Liposomes and nanoliposomes can be manufactured with bilayer permeability responsive to a variety of physical and chemical stimuli, including temperature, light, pH, and ion concentrations. On the other hand, nanoparticles, which contain certain metals including gold, silver and palladium, seem to be ideal components in the formulation of such structures [9]. A schematic representation of a nanoliposome encapsulating metal nanoparticles is depicted in Figure 1. Nanomaterials including metal nanoparticles possess similar dimensions to those of biological molecules. Metal nanoparticles exhibit unique optical and physical properties, such as electronic, photonic, catalytic and surface plasmon oscillations properties [10]. The integration of biomaterials with nanoparticles provides unique recognition, catalytic, and inhibition properties, yields novel biomaterials with synergetic properties and functions. The significance of functionalized nanoparticles for therapeutic and biomedical applications cannot be over-estimated.

2. GOLD NANOPARTICLES

In recent years, the applications of gold nanoparticles expanded into various fields of biomedicine. These fields include biosensors, clinical chemistry, immunoassays, genomics, photothermolysis of cancer cell, microorganisms detection and control, targeted drug delivery, optical imaging and monitoring of biological cells and tissues by exploiting resonance scattering, or in vivo photo acoustic techniques [10, 11]. More recently scientists focused on exploring the unique properties of gold nanoparticles for imaging and therapeutic applications. Engineered nanoparticles were used as nano-platforms for the effective and targeted drug delivery in bio-imaging areas by labelling or encapsulating the nanoparticles with biological, biophysical, and biomedical carriers such as liposomes and nanoliposomes [12]. Several review articles on their basic physical, chemical and optical properties have also been published [10, 13].

Gold nanoparticles conjugated with certain drugs and therapeutic agents created an interesting platform especially for their binding property with many organic and biological molecules, their low toxicity and strong absorption spectrum. Hence, gold nanoparticles played the major role as a carrier for drugs, vaccines and other therapeutic and pharmaceutical compounds to the targeted cells or tissues. In general, the conjugation of the nanoparticles with drugs or biomolecules was performed by modifying the surface of the gold nanoparticles. In case of gold nanoparticles for drug delivery, higher concentrations of drugs with the gold nanoparticles would be required to increase the efficiency of drugs to kill the pathogens [14]. By employing unique physical, chemical and photo-thermal properties of gold nanoparticles, the conjugation and release of drugs into the cells could be controlled [15]. Release of the drug generally involves two processes. These include processes such as internal stimuli operated system, which could occur in a biologically controlled manner, or external stimuli, operated by the support of stimuli-generated processes. A confocal laser microscopy image of lipid vesicles encapsulating gold nanoparticles is presented in Figure 2.

Currently, the focus of many researchers is on the structure divergent synthesis of gold nanoparticles, starting from general colloidal gold nanorods, nanospheres, or silica coated gold nanocubes, nanoshells, nanocages or nanostars [16]. Finally, surface functionalization protocols were developed to be continuously used in various biomedical applications such as conjugation between gold nanoparticles and molecular probes, including polyclonal and monoclonal antibodies (Ab), nucleic acids, oligonucleotides, enzymes, and some therapeutic agents [17].

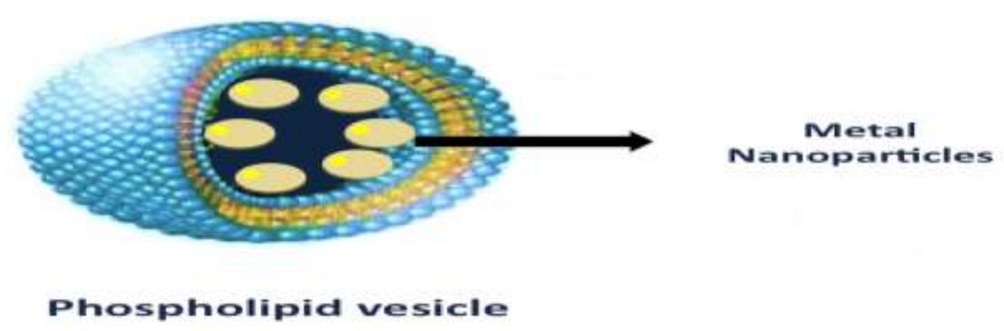

Fig. 2.1 Schematic Presentation of a Nanoliposome Encapsulating Eetal Nanoparticles

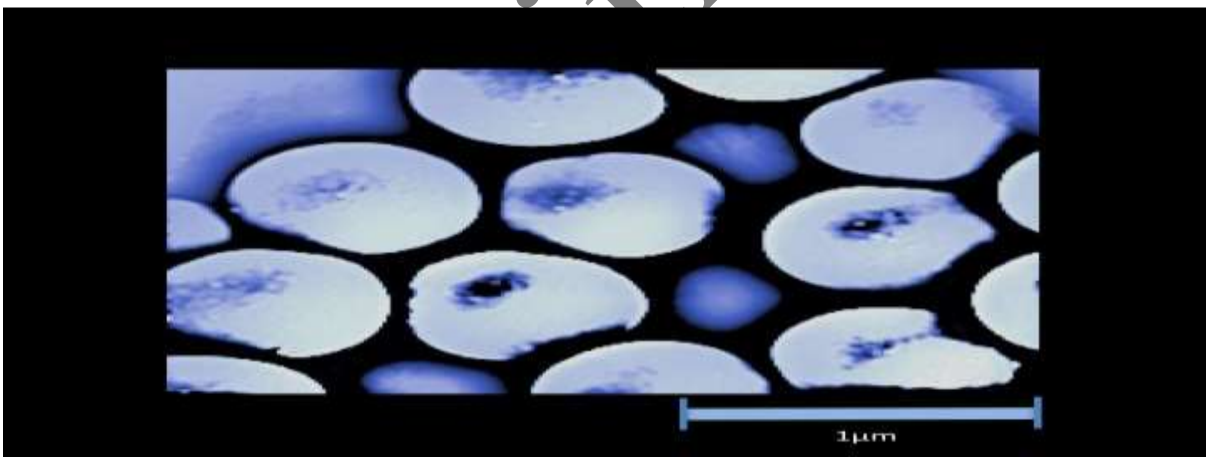

Fig. 2.2 Confocal Laser Microscopy Image of Lipid Vesicles Encapsulating Gold Nanoparticles

3. SILVER NANOPARTICLES

There are several scientific reports showing that various nanoparticles are being applied as targeted biomarkers and drug-delivery agents in the area of diagnosis and medical treatment. Especially, silver nanoparticles have been reported as efficient and potent antimicrobial agents [18]. The importance of bactericidal nanomaterials is because of the increase in the emergence of new resistant strains of bacteria against most available antibiotics. This has promoted research, development and investigation in the well-known property of silver ions and silver-based compounds, including silver nanoparticles. This antimicrobial effect is size and dose dependent and is more pronounced against gram-negative bacteria than gram-positive microorganisms [19].

Bacterial cells have different membrane structures based on which a general classification of them as Gram-negative or Gram positive is possible. The structural differences lie in the organization of a key component of the membrane structure, namely peptidoglycan. Gram-negative bacteria possess only a thin peptidoglycan layer (~2–3 nm) between the cytoplasmic membrane and the outer membrane. However, gram-positive bacteria lack the outer membrane but have a peptidoglycan layer with a thickness of about 30 nm. Silver has long been known to exert a strong toxicity towards a wide range of micro-organisms. Consequently, silver-based compounds have been used extensively in many bactericidal applications [19]. Silver compounds have also been used in the field of medicine and therapeutics to treat burns and a variety of infections [20].

4. SYNTHESIS OF GOLD AND SILVER NANOPARTICLES

Synthesis of gold and silver nanoparticles, particularly the green synthesis of these nanoparticles is a positive step towards the essential need for sustainable and ecofriendly environment. The integration of green chemistry and nanotechnology is one of the most important areas for the nanoscience researchers. The dramatic increase in environmental issues had encouraged the researchers towards the novel green synthesis of nanoparticles in biological systems such as fungi, bacteria and plants [21]. Employment of the plant extracts as the medium of synthesis has attracted significant interest due to its simplicity, robustness and being viable approach. The other reason is due to the fact that the use of plant extracts for the synthesis of nanoparticles does not require elaborate processes. Plant extracts act as natural reducing and stabilizing agents at ambient conditions. Various nanoparticles such as gold, silver, platinum and palladium have been synthesized via different green synthesis processes by many research groups [21]. Synthesis of highly stable silver nanoparticles by the extract of geranium leaves (Pelargonium graveolens) has been reported. The seed extract of Jatrophacurcas was also utilized for the synthesis of silver nanoparticles. Another research group reported the synthesis of gold and silver nanoparticles using a leaf extract of Phyllanthusamarus and Black tea leaf extract [22]. Another study reported the synthesis of gold nanoparticles by lemon grass (Cymbopogonflexuosus) plant extract [23]. The biosynthesized silver nanoparticles using Acalypha indica leaves extract was also reported. Another group of researchers described the production of gold and silver nanoparticles in aqueous solution at ambient conditions using green tea (Camellia sinensis) extract as reducing and stabilizing agent (for a recent review see Ref. [21]). The green synthesis of nanoparticles using various plant extracts appears to be a cost effective and simple alternative particularly for the synthesis of gold and silver nanoparticles.

CONCLUSION

Among different metal particles, gold and silver nanoparticles are especially attractive and useful due to their ease of preparation, large specific surface area, good biocompatibility and high antimicrobial activity. Nanoliposomal gold and silver nanoparticles play a significant role in the field of biology, medicine, food, nutrition, agriculture, and cosmetics to name but a few. Liposomal and nanoliposomal gold and silver nanoparticles find potential applications in the treatment of cancer, in electronics, catalysis, bio-labelling, biosensor devices for the detection of viruses and bacteria, drug delivery, tissue/ tumor imaging and photo thermal therapy. In daily life, liposomal and nanoliposomal nanoparticles of gold and silver are widely used in textiles, shoes, shampoos, soaps, toothpastes, detergents and cosmetic products. Applications of liposomes and nanoliposomes for the encapsulation and delivery of divalent cations such as calcium and trace elements such as selenium in medical field require further attention and research.

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