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AN OVERVIEW ON GOLD NANOPARTICLES(GNPS) AND ITS IMPORTANCE IN CANCER THERAPY

Medical Science

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ABSTRACT

Nanoparticles (NPs) are considered to be the new revolution in the field of medical and Health sciences. These NPs are being used extensively in treatment various heinous disorders most importantly cancer. This review article provides a collaborated studies done recently on Gold Nanoparticles(GNPs) which helps in providing an effective treatment for varied types of cancer. One study stated that Combinational therapies also help in providing an effective decimation of cancer cells. NPs are also said to be used in plasmonic photothermal therapies inorder to eradicate cancer. Another study proves that there was increase in toxicity due to increase in the size of NPs which proves that the size of these particle also play a major role in providing an effective action in curing cancer. In another study, blue mussel Mytilus edulis was observed to experience oxidative stress during exposure to AuNPs for 24hrs. Another study helps us in understanding the importance of Polydopamine enabled surface functionalization of gold coated nanorods which was helpful in providing a light activated photothermal therapeutic response which thereby produces photo induced toxicity of both breast and oral cancer cells which was further followed by NIR irradtion.

KEYWORDS

Nanotechnology; GNPs, Plasmonic photothermal therapy; Combinational therapy; Polydopamine

INTRODUCTION

Nanotechnology is said to be discussing about the design, characterization,production and application of structures, devices and systems by controlling shape and size at a nanometre scale. There are loads of potential benefits of NPs which were recognized in the literature and some of the commentators argued that nanotechnology promises to exceed the impact of Industrial revolution[Fig1]. In the area of medicine research NPs are utilized to enhance drug delivery along with in vitro diagnosis, Novel biomaterial design, bioimaging, therapies and active implants. NPs have lengths ranging from 1 to 100 nm in two or three dimensions. Most studied NPs are carbon nanotubes, Gold nanoparticles and cadmium selenide quantum dots. This review helps in making us understand recent research studies done on NPs in treatment of cancer therapy.

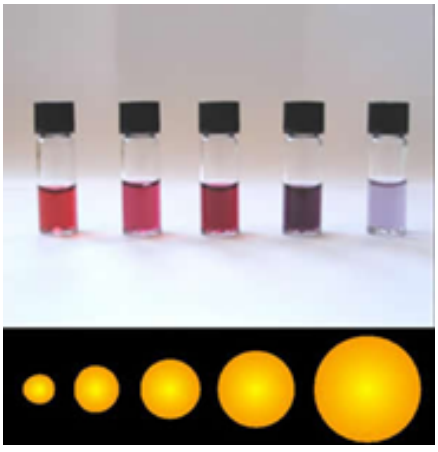

Fig1: Gold Nanoparticles

Nanotechnology is said to be an interdisciplinary research field which involved chemistry, biology, engineering and medicine which has a great potential for early detection and had an accurate diagnosis which includes personalized treatment of cancer. NPs are said to be smaller than variednumber of nanometers in size which is comparable to large biological molecules like enzymes, receptors and antibodies. NPs offered unprecedented interactions with biomolecules both on the surface and also inside the cells which helps in revolutionizing diagnosis of cancer. One of the major applications of nanotechnology was most importantly done in the area of biomedicine. Nanoparticles can be engineered as nanoplatforms for efficient targeting of delivery of drugs and also leads to overcoming of many biological, biophysical, and biomedical barriers by imaging labels.

There are varied subtypes of gold nanoparticles which are based on the size, shape, and physical properties [Fig 2]. The earliest studied GNPs were gold nanospheres. Subsequently, nanorods, nanoshells, and nanocages were also reported. Another type of gold-based nanoparticles, which posses excellent surface enhanced Raman scattering properties. The term "gold nanoparticle(s)" will refer to a collection of all these subtypes and the subtype of gold nanoparticles which were used in each study which were specified whenever possible. Most of these gold nanoparticles was to be produced with well-controlled size distribution, along with stunning precision due to continuous development in the synthesis techniques over the last two decades.

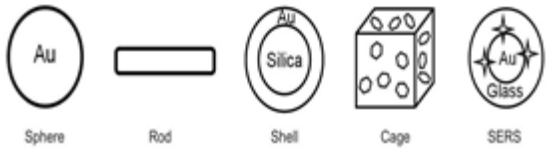

Fig2 : Different types of Nanoparticles

Nanoparticles are said to be of greatest scientific interest as they act as a bridge between bulk materials and molecular structures. A bulk material should have constant physical properties regardless of its size, but in case of a nano-scale size-dependent properties are often observed. Thus, the properties of materials changed as their size approaches the nanoscale and as the percentage of the surface in relation to the percentage of the volume of a material became significant. For bulk materials larger than one micrometer (or micron), the percentage of the surface is insignificant in relation to the volume in the bulk of the material. The interesting and sometimes unexpected properties of NPs are largely due to the large surface area of the material, which causes domination of the contributions made by the small bulk of the material.

Gold Nanoparticles:

Gold Nanoparticles (AuNPs) have been one of the most finest and considered most valuable in treatment for various types of cancer. Nanotechnology is the study of particles in the narrowest dimensions possible. These Nanoparticles are also used in plasmonic photothermal therapy for eradicating cancers. They are also used as Tumor sensors. This treatment has been termed as Nanomedicine by Nation Institute of Health of USA. As these type of Nanoparticles are non reactive they are considered to be useful in various invivo applications. AuNPs are considered to be biologically non reactive due to presence of localized surface plasmon resonance(LSPR)[2][Fig4]. Other than AuNPs there are also varied types of nanoparticles such as Fullerene based Nanoparticles[3] and Magnetic NPs[4][5] which help in treatment of

various Human health diseases. Several studies have proved that AuNPs do not induce any toxicity or adverse reactions[6]. There are varied investigation reports which prove that there was increase in toxicity due to decreasing in the size of Nanoparticles[7].Induction of oxidative stress has been one of the major factors for these type of Nanoparticles to exert cytotoxicty. In another study, blue mussel Mytilus edulis was observed to experience oxidative stress during exposure to AuNPs for 24hrs[8].

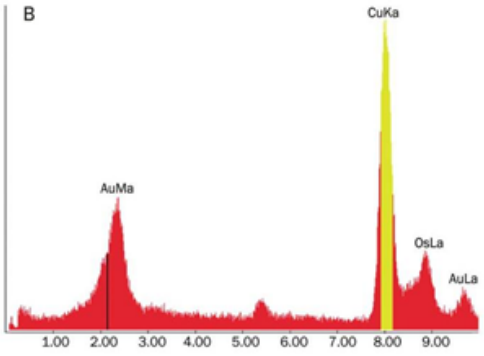

Fig3: Transmission Electron Microscopy of AuNP treated MCF-7 Breast cancer cells[1]

In a review study done by S Jain et;al [9] which collaborated all the studies which showed that NPs act as drug carriers, photothermal agents, contrast agents and radio sensitisers. Another study showed that Nanoparticle functionalisation has been gaining lot of importance in recent days which showed developments in biocompatible, multifunctional particles for use in cancer diagnosis and therapy[10]. Michael Faraday,[11] was the first one to propose the synthesis of GNPs through reduction of aurochloric acid in the presence of phosphorous. Another study which was collaborated in this review showed the evaluation of efficacy of GNPs by using mouse model for treatment against breast cancer cells[12]. Another study done by eminent scholars proved that the EPR effect which when combined with longer circulation times which was often achieved by PEGylation could lead to increase in drug concentrations of drug in tumors by 10-100 fold when comparedwith the utilization of free drugs [13]. Developments in research of tumor targeting was done by performing studies by actively binding tumour-specific recognition molecules such as epidermal growth factor (EGF), transferrin, folic acid to NPs [14][15][16]. Another study proves that GNP–Cetuximab– Gemcita bine Nanocomplex was superior to any of the agents alone or in combination in vitro and in vivo which shows a better accumulation of Gold NPs in concentration[17]. Another study done by Jiang et;al[18] proved that synthesis of citrate coated GNPs with a variable sizes when bound with multiple trastuzumab antibodies which lead to enabling of targeting and cross linking of human epidermal growth factor receptor(HER)-2 in human SK-BR-3 breast cancer cells.

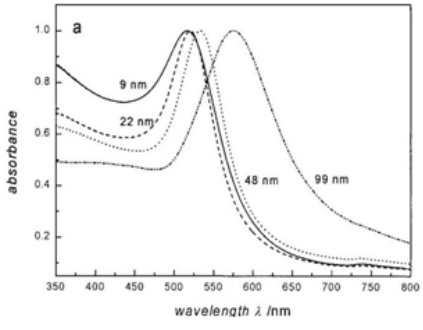

Fig4: Absorption spectra of 9nm,22nm,48nm and 99nm GNPs signifying a change in Surface Plasmon Resonance with particle diameter[2]

These GNPs are also useful as very efficient drug carriers which reduces non specific side effects. Another study proved that GNPs are used as delivery vehicle which was covalently bound to cetuximab and gemcitabine which can be helpful therapeutically in pancreatic cancer[19]. Various studies have proved that Larger NPs have a greater protein to Nanoparticle ratio that that of smaller and curved particles. Hyperthermia is considered to be a heinous disorder which induces apoptotic cell death in most of the tissues which in one of the studies it was proved that GNPs increases local control and over all survival when given in combination with radiotherapy and chemotherapy in randomized criminal trails[20-22]. Hyperthermia is also a condition which is considerably made to undergo through varied combinations with other treatments like radiotherapy which was delivered externally or interstitially in the presence of Heat generation with the help of radio frequency waves and micro waves[23]. This kind of combinational treatment by the help of GNPs help in treatment of many more disorders in future when further more research and analysis is done on this area. Another study done by Rahman et;al [24] analysed invitro radiosennsitising effects of 1.9mm GNPs which have already been used in invivo studies[24][25][26]. In this study, Bovine aortic endothelial cells (BAEC) were made to expose in higher concentrations of GNPs before making it undergo irradiation with X-rays. Some of the studies prove that GNPs causes 30% loss of cell proliferation when it is used alone.

In another study Iron oxide core or GNPs with 30 nm diameter was utilized in demonstrating that GNPs were phagocytosed bypancreatic cancer cells which leads in permitting Magnetic Resonance Imaging(MRI) of sensitizer delivery along with photothermal ablation[27]. In another study which proves that When 15nm AuNPs were conjugated to anti-EGFr antibodies they catalytically aggregate them due to enzyme degradation of antibodies including the shifting of their absorption into the NIR region which further amplifies their photonic absorption. When these anti-EGFr antibodies were used in treatment of human squamous cell carcinoma A431 murine xenografts which was conjugated to AuNPs and NIR resulted in complete tumor ablation without any adverse effects [28]. There have been several authors who tried to bring many more developments regarding the efficiency of NPs in treatment of various tumors. In some of those studies an aptamer switch probe(ASP) which was linked to chlorine e6(Ce6) was developed and was brought to the surface of gold nanorods(AuNRs) which helps in targeting Leukumia cancer cell line for Photodynamic Therapy(PTT).The results of this study have shown that ASP undergoes changes to drive Ce6 away from Gold surface which therefore re3sulted in producing a singlet oxygen for PDT in the presence of Light irradiation[29].

Another study helps us in understanding the importance of Polydopamine enabled surface functionalization of gold coated nanorods which was helpful in providing a light activated photothermal therapeutic response which thereby produces photo induced toxicity of both breast and oral cancer cells which was further followed by NIR irradtion[30]. Another study helped in exploitation of combined photothermal and pharmacological effects. In this study the authors used cytokine tumor necrosis factor-alpha which was conjugated to 30nm gold Nanospheres (Au-TNF) which helps in treatment of murine SCK along with 4T1-GFP breast carcinomas. Then, 2H11 lymphatic cells was heated with the help of laser pulses at varied wave lengths. Then authors tried to anlalyze slightly ellipsoidal NPs which enhanced the photothermal efficiency in near infrared window . The results of this study proved to show higher rate of therapeutic efficacy of Au-TNF conjugates when compared with laser and Au-TNF alone[31].

There are loads of analysis and research to be done to find out many more advantages of GNPs which are becoming essential in treatment of various types of cancers most importantly breast cancer.

CONCLUSION:

Cancer is said to be one of the most deadliest disease which is killing millions of people around the world every year. There have been many therapies like chemotherapy and radiation therapy designed to cure cancer patients. These therapies are said to have varied number of side effects which is effecting the patient who is already suffering with cancer. Thus there was an essential need to discover an effective cancer eradicating material which has no side effects. Nanoparticles(NPs) were considered to be a right choice in eradicating dangerous diseases like cancer. There have been lot of studies done on Nanoparticles and its effective action in curing cancer such as a study stated that

Combinational therapies also help in providing an effective decimation of cancer cells. NPs are also said to be used in plasmonic photothermal therapies inorder to eradicate cancer. Another study proves that there was increase in toxicity due to increase in the size of NPs which proves that the size of these particle also play a major role in providing an effective action in curing cancer. In another study, blue mussel Mytilus edulis was observed to experience oxidative stress during exposure to AuNPs for 24hrs. Another study helps us in understanding the importance of Polydopamine enabled surface functionalization of gold coated nanorods which was helpful in providing a light activated photothermal therapeutic response which thereby produces photo induced toxicity of both breast and oral cancer cells which was further followed by NIR irradtion. Another study proves that when these anti-EGFr antibodies were used in treatment of human squamous cell carcinoma A431 murine xenografts which was conjugated to AuNPs and NIR resulted in complete tumor ablation without any adverse effects. Another study showed that ASP undergoes changes to drive Ce6 away from Gold surface which therefore re3sulted in producing a singlet oxygen for PDT in the presence of Light irradiation. Various studies have proved that Larger NPs have a greater protein to Nanoparticle ratio that that of smaller and curved particles. Hyperthermia is considered to be a heinous disorder which induces apoptotic cell death in most of the tissues which in one of the studies it was proved that GNPs increases local control and over all survival when given in combination with radiotherapy and chemotherapy in randomized criminal trails. Some of the studies prove that GNPs causes 30% loss of cell proliferation when it is used alone. Thus, by considering all of these studies we can clearly come to conclusion GNPs are one of the most vital discovery in the area of cancer research and it is going to become a revolutionizing factor in decimating cancer from this world in coming future.

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Conflicts of interest:

There are no conflicts of interest

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