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Exploring Recent Advances in Nanotherapeutics

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ABSTRACT

Nanotechnology is a rapidly expanding field, encompassing the development of materials in a size range of 5-200 nanometers (nm). The applications of nanotechnology to drug delivery opened the floodgates to create novel therapeutics and diagnostics which have changed the landscape of pharmaceutical and biotechnological industries. Advances in nanotechnology are being utilized in medicine for therapeutic drug delivery and treatment of various diseases and disorders. The biodegradable nanoparticle/nanocarriers, in which drug is dissolved and entrapped are specially designed to absorb the drug and to protect it against chemical and enzymatic degradation. The important role to design these nanostructures as a delivery system is to release pharmacologically active molecules for site-specific action with an accurate dose. In recent times, several biodegradable polymeric nanostructures have been developed with an innate capacity to target specific organs/tissue to deliver the drug. Nanoparticulate drug delivery systems use polymers or lipids as carriers for drugs. Newer polymers engineered to achieve temporal and spatial drug delivery form the mainstay of these systems. In nanotechnology, being tiny molecules of immunotherapeutic have many advantages over biological drugs regarding complexity, tissue penetration, manufacturing cost, stability and shelf life, which is one of dominating therapy in the current research field. The present review gives details about the recent developments of nanostructure drug delivery systems and their applications.

Keywords: liposomes, polymeric micelles, gold nanoparticles, superparamagnetic nanoparticles, solid lipid nanoparticles, aptamers, quantum dots.

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INTRODUCTION

Nanotechnology is a dynamic and multi-disciplinary field, encompassing a plethora of generically distinct spheres such as nanoelectronics, information technology, biotechnology and cellular and molecular biology. In the last two decades, we have seen its profound impact on drug delivery, diagnostics, nutraceuticals and production of biomaterial[1].The development of various novel material processes and phenomena in the nanoscale and the advances in theoretical as well as experimental techniques for research have spawned the development of innovative nanosystems and nanostructured materials[2].The applications of nanotechnology to drug delivery opened the floodgates to create novel therapeutics and diagnostics which have changed the landscape of pharmaceutical and biotechnological industries. Various nanotechnology platforms, either in the form of developmental or clinical stages are being investigated to achieve effective and safer targeted therapeutics for a wide gamut of clinical application[3]. In nanotechnology, being tiny molecules of immunotherapeutic have many advantages over biological drugs regarding complexity, tissue penetration, manufacturing cost, stability and shelf life, which is one of dominating therapy in the current research field[4].

Nanoparticulate drug delivery systems use polymers or lipids as carriers for drugs. Newer polymers engineered to achieve temporal and spatial drug delivery form the mainstay of these systems. Craparo E et al (2008) described the preparation of PEGylated nanoparticles of acryloylated polyaspartamide polymers using rivastigmine as a model drug and their physicochemical and *in vitro* biological characterization[5]. The nanosystems were evaluated for cytotoxicity and their ability to circumvent the macrophage system. Doxorubicin nanoparticles of poly (butyl cyanoacrylate) exhibited efficient brain-targeting in intracranial glioblastoma in rats. Proteins are biodegradable, biocompatible, and versatile and the presence of several synthetic functional groups in protein molecules are potential sites for covalent or non-covalent bonding of drugs. This is exemplified by paclitaxel-loaded albumin nanoparticles which are used for the treatment of metastatic cancer[6].

Kreuter J et al (2007) have described the delivery of apolipoprotein A-I and apolipoprotein B-100 to the brain by

covalently bonding to albumin nanoparticl[7]. Novel injectable nanovectors, which can skirt the macrophage systems, are being used for cancer therapy. These vectors actively bind to specific sites and cells through ligand-receptor interactions. Surface markers like antibodies can be used to maximize specificity. Nanovectors include immunotoxins, dendrimers, polymer-drug conjugates, polymeric micelles, polymersomes, liposomes and metal nanoparticles such as gold nanoparticles or nanoshells[8]. Noble metal nanoparticles (NPs), such as gold NPs, have emerged as a promising scaffold for drug and gene delivery. Gold NPs have unique characteristics which when combined with inertness, low toxicity, ease of synthesis, large surface area, well-established surface functionalization (usually through thiol linkages) and tunable stability provide scientists with exciting delivery strategies. Additionally, the loading of excess pharmaceuticals on NPs allows drug reservoirs to form at the site of administration which ensures controlled and sustained release[9]. Gibson et al (2007) have coupled 70 paclitaxel molecules to gold NPs (e.g. glutathione) with a 2-nm core diameter. The efficient release of these therapeutic agents could be triggered by internal pH or external stimuli (e.g., light) [10]. Without damaging normal human tissue, gold-based nanostructures have enabled photothermal ablation of cancer cells with near-infrared (NIR) light[11].

SELF ASSEMBLED NANOSTRUCTURES:

LIPOSOMES

The last two decades have seen the emergence of self-assembled nanocarriers such as liposomes and polymeric micelles for drug delivery. Liposomes are artificially constructed vesicles consisting of the phospholipid bilayer. Particulate carrier liposomal system could control the drug release and drug targeting. Due to their size and amphiphilic character (besides biocompatibility), liposomes are promising systems for drug delivery[12]. Liposomes have the ability to trap both hydrophobic and hydrophilic compounds to release the entrapped drug at designated targets and avoid decomposition of the entrapped combination[13]. Although liposomes mimic the biomembranes, they are susceptible to mononuclear phagocytic system (MPS) after contact with plasma proteins and are cleared from the blood stream. These difficulties are overcome by the use of synthetic phospholipids, or coating liposomes with amphipathic polyethylene glycol or with chitin derivatives, freeze drying and polymerization[14]. Further, stealth liposomes can be actively targeted with monoclonal antibodies or ligands by synthetic modification of the terminal PEG molecule[15]. Today, liposomes are not only part of vaccines and cosmetics but also many other applications in nanomedicine[16].

Doxorubicin loaded Stealth liposomes, have been developed to treat solid tumors[17]. The stealth principle also extends the circulating time of liposomes which may act as a reservoir for prolonged release of a therapeutic agent. The enhanced pharmacological action of vasopressin was observed when formulated as long circulating liposome[18]. The injectable PEGylated liposomes of doxorubicin are approved for the treatment of acquired immune deficiency syndrome, Kaposi's sarcoma, multiple myeloma, and ovarian cancer[19]. Liposomes have a cell affinity and biodegradability due to which localized delivery can be achieved. They can also change the *in vivo* distribution of loaded drugs and help to improve the therapeutic index of certain drugs[20]. Liposomal encapsulation of drug and protein shows a promising approach for improved drug efficacy i.e. the presence of protein in the liposomal membrane plays an important role in target drug delivery e.g. rifampicin and protein to improve antimicrobial efficiency[21]. Cationic liposomes play an important role to enhance the stability of nucleic acids, to protect and deliver antigens to the antigen presenting cells and thereby stimulating immune response[22].

Liposomal drug delivery systems have many applications in the treatment of patients suffering from cardiovascular diseases, neurodegenerative diseases, diabetes, cancer and inflammation. They also have many applications in pulmonary drug delivery system compared to other carriers as local irritation is avoided; drug toxicity is reduced and drug stability is improved for antiasthmatic, anti-tuberculosis and antiviral drugs[23]. Liposomes have wide applications in localized delivery of therapeutic agents, i.e. cancer therapy. In addition, liposomes could improve the treatment for neurological disorders like Parkinson's disease[24].

POLYMERIC MICELLES (PMs)

H. Ringsdorf and his team in 1984 were the first to explore the use of PMs as drug delivery systems. Subsequently in early 1990s, doxorubicin-conjugated block copolymer micelles were developed[25]. PMs are amphiphilic molecules or copolymers, which can self-assemble into organized core structure in aqueous media at a concentration above their critical micellar concentration CMC[26]. Due to nanoscopic size, PMs have the ability to entrap hydrophobic drugs in large amounts, and achieve site-specific delivery, to obtain desirable pharmacokinetic and biopharmaceutical properties of drugs and enhance their bioavailability.

PMs have a spherical shape and being extremely small (10-1000nm), can penetrate through the cornea. Thus PMs have emerged as the most promising drug delivery platform for the management of ocular diseases like posterior segments of the eye (age-related macular degeneration, diabetic retinopathy, and glaucoma)[27]. Their mucoadhesive nature enables better contact with the ocular surface and ensures better tissue penetration. PMs have also been proven effective for site-specific delivery of anticancer drugs to tumor. Cabazitaxel is a second- generation taxane (noveltubuline inhibitor) which holds great promise for the treatment of castration-resistant prostate cancer. PMs Shows a sustained release profile when loaded with curcumin[28].

Firstly, first generation PM's was only used to solubilized hydrophobic drugs for intravenous administration. But recently, next generation PM's are developed to achieve high encapsulation and retention to maintain prolong circulation after intravenous administration, which is suitable for active and passive drug targeting[29]. PMs have wide applications not only drug gene delivery and diagnostic imaging but also pulmonary sustained release profile, which shows efficient in-vivo release and translation profile[30]. PMs based PH-responsive chitosan shows great potential in cancer Theranostic, due to several superior properties like biocompatibility and photo activated hyperthermia effect[31].

SUPERPARAMAGNETIC NPs

Superparamagnetic iron oxide nanoparticles mainly consist of iron oxide core possessing paramagnetic properties and can be guided to target area within our body through external magnets. A superparamagnetic iron oxide nanoparticle (SPION) encompasses a wide array of applications stretching from diagnosis to advanced cancer therapy, magnetic fluid hyperthermia, magnetic drug targeting, and theranostics[32]. The superparamagnetic properties of iron (II) oxide particles can be used to guide microcapsules to target site by external magnetic fields. Site-

specific delivery of drugs increases the efficacy of the drug and reduces potential side effects. Brazel et al developed poly (N-isopropylacrylamide)-based hydrogels embedded with Iron-platinum NPs. This thermosensitive polymeric system released the loaded drug due to increase in temperature which was facilitated by externally applied magnetic field[33]. Magnetic nanostructures have been developed as theranostic agents who provide dual function of diagnostic and therapeutic agents for diagnosis and treatment of cancers like medulloblastoma and Alzheimer's disease[34].

Superparamagnetic nanoparticles produce heat when kept in an alternating magnetic field. This property of magnetic nanoparticles can be exploited in the treatment of tumors using inductive magnetic fluid hyperthermia (MFH)[35]. Guan Q et al (2020) investigated mesoporous polydopamine carrying sorafenib and. Superparamagnetic iron oxide nanoparticles (SPION) for ferroptosis cancer therapy[36]. The heat generated due to laser irradiation of these particles offered a ferroptosis effect due to an increase in temperature. This nanodrug was guided to the target site by the aid of MRI visible system and external magnetic field. Protein aggregation leading to neural tissue damage due to iron accumulation, oxidative stress, and altered cellular responses are some of the toxicological aspects associated with the use of SPIONs[37].

GOLD NANOPARTICLES

Gold nanoparticles are hybrid materials comprising of gold core which is typically surrounded by organic monolayer. Gold nanoparticles find numerous applications in efficient drug delivery systems as they are easily synthesized, functionalized and are biocompatible due to the inertness of gold metal. Gold-based nanostructures such as nanoshells, nanorods, and nanocages have been used for photothermal ablation of cancer cells with near-infrared (NIR) light without damaging normal human tissues[38]. Melacon et al (2011) studied multifunctional superparamagnetic iron oxide coated gold nanoshells for examination of head and neck cancers[39]. Gold nanoparticles can be synthesized in varied shapes and sizes and possess surface plasmon property. The easy loading of gold nanoparticles with drugs through covalent and non-covalent bonding offers increased therapeutic efficacy. The combination of gold nanoparticles and laser irradiation to control the release of drugs gives useful therapeutic benefits[40]. The gold nanoshells antibody complex has been used in cancer treatment. The gold nanoparticles incorporated with conjugated arginine-glycine- aspartic acid peptide (RGD) and PEG have also shown selective transportation of drugs to cancer cell nucleus. Gold nanoparticles also possess antioxidant properties and act as promising candidates for skin immunization and transdermal delivery system[41].

SOLID LIPID NANOPARTICLES

Solid lipid nanoparticles (SLN) are lipid-based submicron colloidal carriers. Glycerol palmitostearate, lecithin, triglycerides, and tristearinglyceride are mostly used lipids for preparation of SLNs. They need a high amount of surfactants for stability. They can be used by different routes like oral, topical, parenteral, or pulmonary and they remain stable for a long period[42]. Proteins and antigens intended for therapeutic purposes may be incorporated or adsorbed onto these nanoparticles and further administered by parenteral routes or alternative routes such as oral, nasal, and pulmonary route[43]. Special modifications of these nanoparticles can help them to escape immune recognition and thereby enhance their biological half-life. While on the other hand, encapsulation or spreading of proteins and peptides on the surface of SLNs help in bypassing enzymatic degradation in the gastrointestinal tract when administered via the oral route and thereby increasing its oral absorption[44]. Sarmento B et al (2007) demonstrated that insulin loaded solid lipid nanoparticles have shown considerable hypoglycemic effect in diabetic rats when administered orally[45].

On the other hand, administration of important peptides such as cyclosporine A, calcitonin and somatostatin are also being under investigation to potentiate their beneficial effects. Solid lipid nanoparticles can improve ability of the drug to penetrate through blood-brain barrier either by modulating efflux transporters or by targeting specific endogenous receptors on brain endothelial cells and as a result is a promising drug targeting system for the treatment of central nervous system disorders. Erythropoietin-loaded SLN's have shown promising results in improving memory deficits in a rat model of Alzheimer's disease[46]. SLN's offer an extensive advantage in treatment of severe airway diseases and in systemic drug delivery due to their ability for deep lung deposition, prolong release and low toxicity. Developments of erlotinib loaded solid lipid nanoparticle based formulation of dry powdered inhaler have been proposed as promising treatment of Non-small cell lung cancer patients[47]. SLNs loaded with NSAIDs like indomethacin, ketoprofen, isoniazid, and pyrazinamide have also been reported to be targeted to the pulmonary system.

Entrapment of drugs in solid lipid nanoparticles enhanced its permeability by 4-11 times than traditional delivery. Prioxicam loaded solid lipid nanoparticles can be used in treatment of arthritic pain and inflammation when delivered topically. Fabricated prioxicam when loaded in solid lipid nanoparticle gel system increases its therapeutic potential and residence time at site of inflammation and in systemic circulation[48]. A non-selective vasodilator drug sildenafil is in high demand for treatment of pulmonary arterial hypertension but there are higher incidences of intra alveolar bleeding when administered in its free form. Nanoencapsulation of sildenafil has been proven to be beneficial in *in vivo* studies on rats in preventing its potential side effects[49].

Solid lipid nanoparticles offer an edge over advantage of excellent bioavailability, production scalability, and higher drug loading capacity with consolidation of both hydrophilic and hydrophobic group and lower cytotoxicity in comparison with polymeric micelles[50, 51].

APTAMERS

Aptamers have recently emerged as a novel class of ligands with excellent potential for diagnostic and therapeutic agents[52]. Aptamers are finding niche in cardiovascular diseases with the help of targets like von Willebrand factor, thrombin factor IX, phospholamban, P-selectin, platelet derived growth factor, integrin αvβ3, vasopressin, etc[53]. Aptamers are a well-defined, folded, three dimensional structures of small single-stranded nucleic acids which inhibits biological functions by showing a high affinity and specificity for their target molecules. Aptamers belong to the family of nucleic acids and can be synthesized by chemical or enzymatic procedures, or a combination of the both[54]. Aptamers can be used in therapeutics in a similar way to that of monoclonal antibodies. Aptamer targeting can be developed for intracellular, extracellular and cell surface targeting[55]. Aptamers can be used in cases where extracellular blockade of protein-protein interaction is required. They are currently undergoing clinical evaluation

of ocular diseases, hematological diseases and cancer[56]. Aptamer technology has been applied in *in vitro* diagnosis, *in vivo* imaging, and targeted therapy as well as in biomedical fields for the discovery of biomarkers. Aptamer-drug conjugation (ApDC) is a model of conjugating aptamer sequences with therapeutic agents covalently or noncovalently[57].

Various other studies also utilized aptamer-dox conjugates for cancer therapy, such as human epidermal growth factor receptor 2(HER2) aptamer-Dox conjugates for breast cancer targeting[58]. Mucin1 (MUC1) aptamer-Dox conjugates for lung cancer targeting and prostate specific membrane antigen (PSMA) aptamer-doxorubicin conjugates for prostate cancer targeting. Incorporating AS1411 (guanosine rich oligonucleotide aptamer) aptamers into deoxyribonucleic acid (DNA) pyramid selectively inhibits the growth of cancer cells without the use of transfection reagents[59]. Various aptamer-based drug delivery systems include AS1411 (guanosine rich oligonucleotide aptamer) for treatment of leukemia, Emapticap pegol (NOX-E36) for treatment of type 2 diabetes mellitus and regulatory subunit (REG1) which is used in treatment of coronary artery disease[60].

POLYMERIC NANOPARTICLES

To mask the physico-chemical intrinsic property of a substance to facilitate their skin penetration, polymeric nanoparticles encapsulated active drugs are used. The presence of oil in the nanocapsules results in forming vesicular structure while its absence in nanospheres gives a matricial organization of the polymeric chains[61]. Recently, researchers have developed a new magnetic nanostructure that can be used to detect and destroy β-amyloid protein oligomers, which is a causative factor in Alzheimer's disease. The magnetic nanostructures can be used for imaging, as the nanoparticle acts as a magnetic resonance imaging contrast agent[62].

Biodegradable nanoparticles are used frequently as drug delivery vehicles because of their better bioavailability, better encapsulation, controlled release and less toxic properties, they are widely used in the delivery of cytotoxic drugs, deoxyribonucleic acid delivery and antiviral drugs[63]. Entrapment of cytotoxic drugs in polymeric form results in the improved specificity towards and reduces toxicity nondiseased cells. Owing to their polymeric nature and size (200 nm) they are more stable than liposomes during storage. Biodegradable nanoparticles are also used for the genetic engineering of human stem cells for enhanced angiogenesis[64]. One of the antiviral drug delivery applications of polymeric nanoparticles is the intracellular delivery vehicle for saquinavir designed by loading saquinavir into poly ethylene oxide-modified poly-epsilon caprolactone nano-particulate system[65].

Also, to enhance percutaneous transport into across skin barrier, polymeric nanoparticulate systems have been proposed[66]. Multifunctional polymeric nanoparticles as a vehicle for anticancer therapeutics is new field which causes the nanoparticles to accumulate at the tumor site, resulting in the localization of more drug at cancer site[67]. Gene silencing using small interfering RNA has several potential therapeutic applications. A cationic polymer, polyethylenimine was incorporated in the poly lactic glycolic acid matrix to improve siRNA encapsulation in the poly lactic glycolic acid (PLGA) nanoparticles. Serum stability and lack of cytotoxicity add to the advantage of the poly lactic glycolic acid polyethylenimine (PLGA-PEI) nanoparticle in Gene silencing based application of biodegradable polymeric nanoparticles[68]. Another application is insulin loaded polymeric nanoparticles for oral delivery of insulin. They were prepared by water-in-oil-in-water emulsifation and evaporation method by using polymers like poly ε-caprolactone, and positively charged non-biodegradable polymer (Eudragis RS®)[69].

QUANTUM DOTS

Quantum dots (QDs) are also known as nanoscale semiconductor crystals. They were first described in 1981, with the first biological imaging application was outlined in 1998, since that the field of quantum dots has been growing steadily. Now it includes application in fields of drug delivery, biomedical imaging and so on. These nanometeric semiconductors offer several optical properties, such as high quantum yield, size tunable light emission and good chemical and photostability[70]. QDs are fluorescent, inorganic, semiconductor nanoparticles which are 2-10 nm diameters. The achievement of using these quantum dots in biological imaging, sensing and detection has encouraged scientists to further improve this technology in other application of medicine[71].

Recently it is studied that QDs can be used to image cancer cells by their ability to display the superior fluorescent properties compared to conventional chromophores and contrasting agents. Copper-Indium-Sulphur/zinc sulphate QDs as 'all-in-one' theranostic nanomedicine possesses intrinsic imaging and therapeutic capabilities within a well-defined nanostructure. These metallic QDs have the ability to mediate photoinduced tumor ablation[72]. Carbon QDs is a potential material in diverse fields of biomedical application as well as a preferable choice in various biomedical applications as nanocarriers for drugs, therapeutic genes, photosensitizers, and antibacterial molecules[73]. Carbon dots or C-dots emerging and versatile nanomaterials and its application can be found in imaging in the field of medicine. Table no. 1 shows carbon nanomaterials based drug targeting systems[74].

QDs have a potential for better treatment of cancer by targeted drug delivery systems. Apart from targeting of anticancer drugs, QDs are also useful to deliver other biomolecules such siRNA[75]. QDs are also a part of drug delivery, one example is chitosan encapsulated zinc oxide quantum dots was formulated for tumor targeted drug delivery. Chitosan enhanced the stability of QDs which resulted in the long term fluorescence stability for design[76]. The research of multifunctional graphene quantum dots made ease for the simultaneous targeted cellular imaging and drug delivery for lung cancer targeted drug delivery, the pH sensitive zinc oxide (ZnO) quantum dots made of doxorubicin nanoparticles were formulated[77]. They were synthesized as nanocarriers with ultra-small size (3 nm), introduced to dicarboxylated polyethylene glycol which had been introduced to ammonia-Zinc oxide QDs which provided stability under physiological fluid[78]. Table no. 2 shows FDA approved nanomedicines [79-81].

Table 1: Carbon nanomaterials based drug delivery system[74].

Technology	Loaded Drug	Ligand	Targeted cell
Carbon-dots	Doxorubicin	Nuclear localization signal peptide	A549 (adenocarcinomic human alveolar basal epithelial cell)
Carbon-dots	Doxorubicin	Folic Acid	HeLa(derived from cervical cancer cell)

Table 2: FDA approved nanomedicine [79-81].

Technology	Formulation	Name of the Product	Company	Indication	Clinical trials/ Approval year
Liposome	Daunorubicin	DaunoXome®	Galen	Sarcoma	1996
Liposome	Vincristine	Marqibo®	Onco TCS	Acute lymphocytic blood clot	2012
Liposome	Morphine Sulphtae	DepoDur®	Pacira Pharmaceuticals	Loss of pain due to surgery	2002
Polymeric Micelles	Estradiol Protein NPs.	Estrasorb™	Novavax	Hormone therapy	2003
SPION	Dextran	Feridex®/ Endoderm®	AMAG Pharmaceuticals	Imaging materials	2008
Polymeric Nanoparticles	PEGylated factor VIII	ADYNOVATE	Baxalta	Hemophilia	2015
Polymeric Nanoparticles	PEGylated antibody fragment(certolizumab)	Cimzia®	UCB	Chorn's disease, rheumatoid arthritis, psoriasis	2013
Aptamers	Mucagen	Pegaptanib	Eyetech Pharmaceuticals/ Pfitzer	AMD Diabetic Retinopathy	Approved
Gold Nanoparticles	Silica nanoparticle with gold shell	AuroShell®	Nanospectra Bioscience	Prostate neoplasm	2012

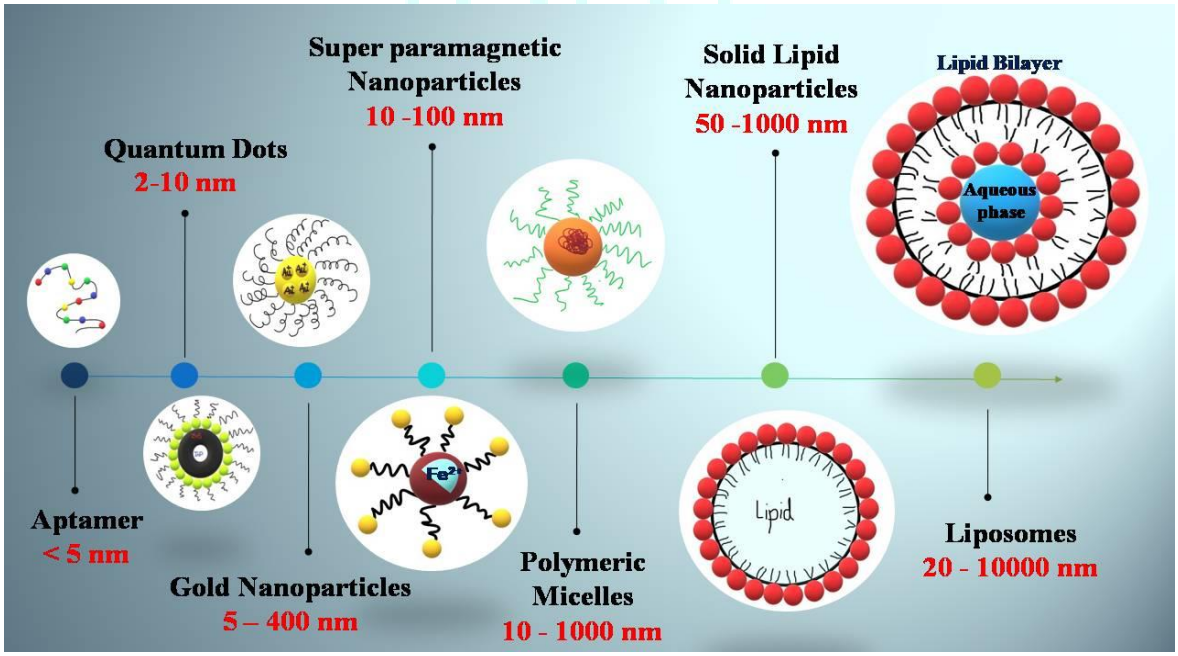

Figure 1: Diagrammatic representation of various nanostructures

CHALLENGES OF NANO DRUG DELIVERY

Nanotechnology in drug delivery has achieved great success as evidenced by some nano drug products in the market. However, there are numerous challenges associated with nano drug delivery. These include circulation time in the blood, increased surface area, protection of loaded drug from degradation, ability to cross biological barriers and site-specificity. Most of the nano drug delivery studies are carried out by academic researchers. There are many regulatory challenges too with advancement in nano drug delivery technology. Having different regulations for physicochemical and pharmacokinetic properties of nano drug products, which are different from conventional drug products, is need of the hour. The United States' Food and Drug Administration (FDA) and the European Medicines Evaluation Agency (EMEA) have taken proactive steps to identify some possible scientific and regulatory challenge. Since the last two decades, effects on environment are being scrutinized by the regulatory authorities and scientific community. Attention has been more focused on engineered nanoparticles, like carbon60 and quantum dots. Large scale production of nanomaterials is another major challenge for the industries. A number of nano drug delivery technologies are not scalable due to the method and process of production and variable costs of materials used. The various challenges of scaling up include low concentration of nanomaterials, agglomeration and processing. It is easier to modify nanomaterials at laboratory scale than at large scale or manufacturing scale without compromising on the size and composition of nanomaterials. Thus a series of coordinated efforts are required to overcome the challenges associated with this very exciting drug delivery platform.

CONCLUSION

From the above points, it is concluded that the Nanotherapeutics is a wide and emerging section in the field of medicines containing myriad of beneficial attributes. Self-assembling nanostructures like liposomes and polymeric micelles can serve as a promising tool for efficient drug delivery and drug targeting. Nanostructures like solid lipid nanoparticles, gold nanoparticles, superparamagnetic nanoparticles, aptamers have a wide array of application from drug targeting to advanced cancer therapy. Quantum dots have major application in diagnosis of cancer and imaging. Along with all these applications, Nanotherapeutics offers versatility and holds a considerable potential in market.

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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