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Mini Review

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Nanocarriers

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ABSTRACT

Nanocarriers are one class of nanomaterials. They are finding increasing application in several realms, particularly as chemotherapeutic agents in the treatment of cancer. They have certain properties that allow them to fulfill their roles. Amongst these are their small size, large surface area, heavy loading and release of drug. There are several types of nanocarriers and these can be modified accordingly to have hydrophilic groups which will increase their penetration of tissues. The major classes of nanocarriers include polymer conjugates, polymeric nanocarriers, polymersomes, polymer-drug conjugates, lipid-based carriers, peptide nanocarriers, dendrimers, carbon nanotubes, gold nanoparticles, quantum dots, magnetic nanoparticles, solid lipid nanocarriers (SLC), nanostructured lipid carriers, nanoemulsions, nanospheres, nanocapsules and electrosomes, etc. Each class also has its advantages and disadvantages. One disadvantage of nanocarrier is their toxicity and this vary with type. Recent advances in the design, synthesis and utilization of nanocarriers include the synthesis of electrosomes, hyperbranched nanocarrier, nanogels, peptide and protein nanocarriers.

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Introduction

A nanocarrier is nanomaterial of submicron size being used to transport a molecule, such as a drug to another site or target site. It's of high versatility. Commonly used nanocarriers include micelles, polymers, carbon-based materials, liposomes and other substances [1]. It was first reported in early 1960's, and since then research has grown significantly in pursuit of the best nanocarrier.

Nanocarriers range from sizes of diameter 1-1000 nm [2, 3]. Nanocarriers have distinct properties that enable them to perform their activities. These include: quantum effects, a high surface to volume ratio and their ability to carry molecules to their target site due to their nanosize [4]. The small size of nanocarriers allow them to deliver drugs to otherwise inaccessible sites around the body. The small size of nanocarrier allow for large drug doses. Its easy to customize nanocarrier size, charge, surface properties and targeting moieties to regulate their uptake, biodistribution, targeting and elimination [5]. Nanocarriers are administered via several routes. These include: parenteral, nasal, topical and oral routes [6-9].

Nanocarriers can be classified into several types. These include polymer conjugates, polymeric nanocarriers, polymersomes, polymer-drug conjugates, lipid-based carriers, peptide nanocarriers, dendrimers, carbon nanotubes, and gold nanoparticles, quantum dots, magnetic nanoparticles, solid lipid nanocarriers (SLC), nanostructured lipid carriers and nanoemulsions, nanospheres, nanocapsules, electrosomes, etc. Lipid-based carriers can be subdivided into liposomes and micelles. Gold nanoparticles include gold nanoshells and nanocages. Using different types of nanomaterial, nanocarriers allows for variation in their hydrophobicity and hydrophilicity. Thus, allowing them to transport hydrophobic or hydrophilic drugs to different target sites throughout the body. For example, Micelles contain either hydrophilic or hydrophobic drugs depending on the orientation of the phospholipid molecules. Since the human body contains mostly water, the ability to deliver hydrophobic drugs effectively in humans is a major therapeutic benefit of nanocarriers. Some nanocarriers incorporates nanotube arrays allowing them to transport both hydrophobic and hydrophilic drugs [10-14].

Nanocarriers are used in several realms. However, their main use is in chemotherapy in the treatment of cancer [15]. They can lower the toxicity of many chemotherapeutic drugs, since they can target the smaller pores, lower pHs and higher temperatures of tumours. Most of the anticancer drugs reported to date are hydrophobic in nature. However, the solubility of these drugs is improved via the incorporation of micelles to stabilize and mask the hydrophobic nature of drugs [16]. Nanocarriers have other applications such as their use in cosmetics to offset problems with bioactive substances, including poor stability, solubility in water or penetrating ability or management of their release [17]. Nanotechnology via nanocarriers has revolutionized the use and commercialization of cosmetics. For example, since 2000, there has been a significant increase in the global sales of cosmetics. A compound annual growth rate (CAGR) of 4.5% has been noted due to nanocarriers.

Each class of nanocarriers has its advantages and disadvantages. For example, nanoemulsions (Nes) are isotropic dispersed systems of two non-miscible liquids such as oil-in-water system (O/W) or water in oil (W/O) system, forming droplets or oily phases at the nanoscale [18]. Nanoemulsions, because of their smaller particle size, provides higher stability. Its highly suitable for carrying active ingredients and thus can extend the shelf life of cosmetics [19]. Nanoemulsions are widely used. However, they have certain disadvantages. These include their high cost and complexity of production. In addition, high energy is necessary to generate small droplets. High speed emulsifiers are necessary for their preparation. Thus, the high cost of purchasing equipment. In addition, nanoemulsions is a liquid preparation. Hence, its not stable as solid preparation and the shelf life is short.

Solid Lipid Nanocarriers (SLNs) are made of solid lipid, an emulsifier and aqueous substance. However, it has a low payload in some drugs. In addition, the drug is expelled during storage. Thus, they have been superseded by Nanostructured Lipid Carriers (NLCs). The presence of solid and liquid lipid core boosts the amounts and loading efficiency of SLNs [20]. SLNs and NLCs have some disadvantages. Their loading efficiency decreases due to their complex crystallization. NLCs are also faced with particle growth [21].

Liposome, another nanocarrier is between 20 to 100 nanometres in diameter. They are made of phospholipid bilayers, as it contains polar head which is hydrophilic and hydrophobic tails. There are hydrophobic substances amongst the bilayers and hydrophilic materials inside and outside of the layers. Liposomes operate via endocytosis [19]. One of the problems with liposome is their solubility. Thus, appropriate solvent has to be sought [17].

Mini Review

The use of nanocarriers has been increasing around the globe. Five articles were reviewed in this paper. A review of nanocarriers-Mediated Drug delivery system for anticancer agents has been reported1. In that review, several nano-drug delivery systems designed for tumour-targeting are evaluated in preclinical and clinical trials and have shown promising outcomes in cancerous tumors clinical management. It describes nanocarrier's importance in managing different types of cancers and emphasize nanocarriers for drug delivery and cancer nanotherapeutics [1].

Electrosomes which are self assembled nano structures made up of amphilic molecules and which can be charged by an electric field have recently been used to deliver drugs or other therapeutic agents to specific areas of the body [22, 23]. Electrosomes are good nanocarrier for the transport of chemotherapeutic drugs to cancer cells at high dosage, while minimizing damage to healthy cells. They may also be used to deliver proteins, peptides etc. to target cells which may be difficult to deliver using traditional drug delivery methods [22, 23].

Very recently, the development of biodegradable polyester based hyperbranched nanocarrier modified with N-acetyl glucosamine for the efficient drug delivery to cancer cells via glucose transporters, GLUTs has been reported [24]. The complete nanocarrier was characterized by HNMR, dynamic light scattering and FTIR spectroscopy [1]. N-acetyl glucosamine imparts water solubility to the nanocarrier allowing for better permeation of the human biological system. This modification allows for greater targeted delivery of the drug [24].

Nanogels, as a novel nanocarrier systems for efficient delivery of CNS therapeutics has been noted by a research team. Nanogels have great ability to deliver therapeutics drug to target tissues. This is due to their high colloidal stability, high drug loading, core-shell structure, good permeation property and responsiveness to external stimuli. They are superior in comparison to conventional therapeutics in permeating brain parenchyma under in vitro and vivo conditions. Therapeutics for the treatment of CNS diseases are hampered by the presence of blood-brain barrier and blood-cerebrospinal fluid barrier (BCSFB). Hence, the development of novel carriers in nanogel offers great relief for the treatment of CNS diseases [25].

Nanosponges are another form of nanocarrier. They are capable of carrying both lipophilic and hydrophilic drugs to target sites within the human biological system. They also improve the solubility of poorly water-soluble molecules. Nanosponges are tiny sponges, with the size of a virus and a three-dimensional network. They can be filled with a variety of drugs to form a porous insoluble nanoparticle, with a crystalline or amorphous structure with spherical shape. They are also cite specific, allowing them to be effective at a particular dosage. A review article on nanosponges has been noted [26].

A review article describing various nanocarriers, investigated for the delivery of proteins and peptides to augment their clinical applications have been cited27. Various biological aspects of protein and peptide delivery have been focused on. Nanocarriers can overcome various biological barriers and improve the delivery of therapeutic biomacromolecules such as proteins and peptides [27].

Conclusion

Nanocarriers are one form of nanomaterials. They are used primarily for the transport of drugs to specific site within the human biological system. They possess certain unique properties that make them superior over conventional carriers. They are design and synthesized in different forms and shape. The various forms have several advantages and disadvantages. Their effectiveness is increased via the incorporation of hydrophilic centres to the molecule. The design, synthesis and use of nanocarriers have been on the increased and are noted in the literature. Amongst novel ones synthesise to date include electrosomes, nanogels, nano sponges, polyester based hyperbranched nanocarrier etc.

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