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Pharmaceutical Nanotechnology: A Rising Tide of Challenge & Opportunities

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Review Article

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ABSTRACT

Today's, nanotechnology is integral part of pharmaceutics and Drug delivery system. In pharmaceutical science size is an important matter because it influences the drugs bioavailability; toxicity reduction; and better formulation. Nano size enhances drug performance many fold. It provides intelligent systems, devices and materials for better pharmaceutical applications. This review paper focuses on the pharmaceutical aspects of nanotechnology for future prospects.

INTRODUCTION

In Latin script 'nano' means dwarf. Nano science is study of matter at nano-scale dimension and nanotechnology is practical application of this technology in everyday life [1-5]. In common word nanotechnology are science deals with material with size below 100nm (billionth of a meter). It can be describe as exploitation of materials with structural size range between atom and molecular scale. There are many examples from nature like H_2O molecules, RNA, DNA, virus, and RBCs etc. [6-10].

Opportunities and Scope

Poor solubility is a major challenge for pharmaceutical industries. It was found that up to 40% new drugs fail because of insolubility. That problem may be resolve to some extends with nanotechnology. Nanotechnology is an emerging science which can change the way of disease treatment and drug delivery [11]. One of the most common challenges we face in cancer treatment is hydrophobic nature and poor solubility of anticancer drugs. For example, Paclitaxel is a potent anticancer drug that is widely used in the therapy of solid tumors. But it is poorly soluble in aqueous solvent. This was resolved with the help of formulations of paclitaxel based on nanotechnology [12].
Rungsiyanont et al. investigated the biocompatibility of Gelatin-Hydroxyapatite (Crosslink Biomimetic Scaffolds) for Bone Regeneration [13]. Liposomes and fluidized magnetic nanoparticles have increased the intratumoral accumulation of doxorubicin and hence increase the chemotherapeutic bioavailability [14].
Pharmaceutical nanotechnology comprises synthesis, characterisation, clinical trial and toxicological aspects of nanomaterial in health therapy.

Synthesis of Nanoparticle

Because of immense capability, scientist around world is looking for fast and economically feasible method for nanoparticle production. Biological synthesis of silver & iron oxide nanoparticle by using different strains of bacteria

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is one of the steps toward this [15]. Bacterial strains C17 and C21 had ability to produce hydroxyapatite nanocrystals. These strains are phosphate positive and produce insoluble mineral phosphate [16].
Plant may be exploited for the production of nanoparticle specially Aloe vera. A group of scientist proved that silver and iron nanoparticle obtained from aqueous plant extract were showed better antibacterial activity as compare to other one [17]. Similar experiment was conducted by Montasser et al. in gold nanoparticle preparation using algae as bioagent. Conventional approach is expensive and they require toxic chemical [18].

Characterisation of Nanoparticle

Scientists are searching for new nanomaterial with characteristic properties. Deoxyribonucleic acid (DNA) emerges as potential nanomaterial with unique structural properties [19]. Wang et al. reported that Graphene oxide as coating on solid state substrate were found to be enhancing mammalian cell growth [20]. Graphene is packed into a two dimensional honeycomb lattice. It is a monolayer sheet of carbon atoms [21]. Polyphenols are naturally occurring phytochemical that are found to be effective antioxidant, anti-inflammatory, anti-aging agents [22].

Clinical trial and Toxicological Aspects

Diagnosis and therapy are two important aspects of healthcare system. Nano size material plays a vital role in development of these two fields. Israel et al. reported the application of different nanostructured materials in multifunctional nonmedical platforms [23]. Nanotechnology can sort the problem for oral administration of insulin. Nanoparticles protect insulin protein against degradation and facilitate the easy cellular absorption [24]. We are familiar with vitamin K3 and their role in our body. Heli conducted an experiment where he observed the electrochemical behaviour of vitamin K3 in presence of human serum albumin with the help of carbon nanoparticle [25].

Gold nanoparticle has found to be effective immune stimulator as it increases WBC count and restore macrophage count. The immune-potentiation property of Gold nanoparticle may be utilized in certain immunodeficiency problems (due to microbial infections, AIDS and Chemotherapy) [26]. Dieni et al. investigated the effect of Gold nanoparticle (nAu) on ligand binging properties of bovine serum albumin [27]. A group of scientist reported that zinc ferrite nanoparticle is more effective contrast agent in compare to conventional contrast agent gadolinium Gd (III) in magnetic resonance imaging (MRI) [28]. Patil et al. compared the antimicrobial activity of copper and silver nanoparticle. They concluded that CuNP is more efficient in compare to AgNP and their combinations [29].

Olson et al. observed increase in retinal electrical activity after intravitreal injection of photoactive quantum dots in the RCS rat model. They suggested a promising role of this technology in progressive retinal degenerations [30]. Drug Copaxone and Interferon were commercially used for the treatment of demyelization disease (multiple sclerosis). When these drugs are released with nanostructured SAB-15 the drug compound occupied the empty spaces inside and on the surface of the sample [31]. An interesting experiment was conducted by Azarnova et al. on embryogenesis of chicken. They observed that nanostructured complex suppressed the peroxidase activity and increase superoxide dismutase many fold [32].

Applications of Pharmaceutical Nanotools

Nanosensors

Traditional diagnostic techniques taking much time in disease diagnosis causing serious delay in patient care or some time lethal. Nano techniques allow for rapid and ultra-sensitive detection of biological analytes. With advancement in nanotechnology the development of plasmonic sensors has expanded significantly [33]. Medical diagnosis now became easier with the discovery of nanoparticles (nanotubes, fullerenes, gold and silver nanoparticles, diamondoids, quantum dots etc.). But before application it should be mandatory to assess its toxicity in human body [34].
A novel biosensor was developed which can detect Salmonella typhimurium carrying SSeC gene [35]. This biosensor should be potential alternative to the convention detector.

Drug delivery system

Major challenge in cancer treatment is effective delivery of drug to target organ with any side effect. Now

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pharmaceutical researcher applying nanocarriers like nanosphere, nanocapsules, micelles, liposomes, gold nanoparticle for better drug delivery [36]. Similar investigation was done by Nirmala et al. for possible use of micro emulsions as potent drug delivery system. This could be administered through various roots as ophthalmic, nasal, and oral [37].

Synthetic biopolymers are recently applied in drug delivery system open new windows for future drugs [38]. Christianah et al. concluded that, acetylated cassava starch could be a good stabilizer and vehicle for drug delivery [39].

Silica nanoparticles were evaluated for successful delivery of quercetin natural product. It showed antioxidant, ant-inflammatory, and anti-cancer activities. Silica nanoparticle enhances bioavailability of quercetin [40]. Throughout world different metal are tested for quality nanomaterial [41-50].

Nanomaterial's for tissue engineering

Nanostructured calcium phosphates can play a vital role in tissue engineering scaffolds, drug delivery systems, vaccine adjuvants, contrast agents for imaging and multi-modal imaging, and antifungal/antibacterial agents [51]. Advance 3D printing is rapidly growing technique in the fabrication of tailored prosthetics, medical implants, new drug formulations and the bioprinting of human tissues and organs [52].

Cancer treatment

Treatment of cancer is going complicated because of resistance towards drugs. Nanomedicine should overcome this problem by lowering side effect to normal tissue and enhance efficiency of drugs [53]. Normally cancer drugs inhibiting the growth of rapidly dividing cell. But they also interact healthy one and inhibit DNA synthesis. Therapeutic drug delivery minimizes the chances of interaction with non-tumour cells. There are three main methods for creation of nanocarriers i.e. nanoprecipitation, single emulsion and double emulsion [54].

Silver sulphide nanoparticle is emerges as new hope for the treatment in cancer therapy. It causes photo thermal destruction of cancer cells at proper laser dose [55]. A group of scientist recommended silver nanoparticle for treatment of lung cancer. Ag NPs used as photo synthesizer causing DNA damage in cancer cell [56].

Challenges to pharmaceutical nanotechnology

Pharmaceutical Nanotechnology is provided a platform for new drug development. However it faces some ethical, social and regulatory issues posing serious challenges in practical application. Some ethical issues are anomaly in gene/ cell behaviour, gene expression and ultimate fate of long term exposure. There is no FDA directives to regulate pharmaceutical nanotechnology based products and related issues. The characterization, safety and environment impact are three main elements that need to be regulated [57-99]. Nanotechnology is occupied a place in human life for example textiles, electronics, computer and pharmaceutical industries etc. But in food industries its application is very less because of sensitivity and complex structure [100].

CONCLUSION

Traditional drug development takes 10-15 years and investment of huge amount of money. On the other hand Nano medicine could nearly takes 3-7 years only with will not require much money. But the major challenge is screening of disease drug pair [101]. Pharmaceutical nanotechnology provides us cutting age technologies over conventional technologies. Nanotechnology has enormous potential to make significant contributions to disease detection, diagnosis, therapy, and prevention [102-105]. Pharmaceutical nanotechnology could have ability to sort out problem at cellular level and can make clear differentiation between normal and abnormal cell. However going towards bottom size increases the unknown health risk.

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