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Editorial

A Short Overview on the Nanoparticle-Based Smart Drug Delivery Systems

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Editorial

Recently, nanotechnology has been extensively used in different areas such as catalysts, biosensors, food industry, pharmaceuticals as well as gene delivery, etc. Nanoparticles are particles with size ranged between 1 and 100 nanometers and may exhibit size related properties that differ significantly from those observed in their own bulk materials [1-3].

Pharmaceutical nanoparticles, can beneficially enhance therapeutic efficacy by improving the drug bioavailability [4,5]. Controlled release formulations based on nanoparticles provide better penetration and allow slow and controlled release of active pharmaceutical ingredients at the target site [6-9].

There are many types of drug delivery systems, which have been developed for targeted and controlled release purposes. Smart or intelligent drug delivery systems are the main group of these systems which are capable to adjust drug release rates in response to a trigger[10,11]. These systems are divided to two groups: open-loop control systems and closed-loop control systems[12]. In open-loop control systems external triggers e.g. magnetic, thermal, ultrasonic, and electric are essential for drug release while in a closed-loop type, the drug release rate is controlled without any external intervention[13]. The drug release from the latter group is controlled by an internal trigger such as: pH or temperature - responsive drug delivery systems, urea-responsive drug delivery systems, glucose-responsive insulin delivery systems, inflammation-induced pulsatile release systems, morphine triggered naltrexone delivery systems, the systems utilizing molecular targeting agents such as antibody or aptamer and the systems utilizing chelation[13,14].

Variety of molecular targeting agents have been documented such as enzymes, humanized antibodies and single-chain Fv generated from murine hybridoma or phage display, aptamers, mini bodies and peptides[15-17]. The drug delivery systems that utilize these agents are developed to various applications such as isolation, detection and release of therapeutic agent[18]. From the pharmaceutical point of view, functionalization of the nanoparticles with molecular targeting agents has shown promising application in the biomedical areas[19,20].

Biodegradable and biocompatible smart polymers are able to release the entrapped drugs at the appropriate time and site of action in response to specific physiological triggers. The responses may alter from swelling/contraction to disintegration [15,21,22]. Aliphatic polyesters, such as polylactic acid (PLA) and polyglycoli cacid (PGA), as well as their copolymer polylactic-co-glycolic acid (PLGA) are the mostly used polymers in developing controlled release nanoparticles. Chitosan and its derivatives are very beneficial materials for drug delivery purposes. Chitosan nanoparticles targeted using magnetic nanoparticles, antibodies or aptamers have been assessed for crossing from the blood-brain barrier[23].

Mesoporous silica nanoparticles can apply as stimuli-responsive materials to create smart delivery systems. Targeting agents such as nucleic acids can be employed to cap the pores of these nanoparticles as biomolecular cap and therefore these nanoparticles can act as gate keepers. Either intracellular or external triggers, such as changes in pH, light, enzymatic activity, electromagnetic field or ultrasound are applied to remove the cap from nanoparticle, which result in the release of drug. Furthermore, optical and magnetic contrast agents can also be introduced into nanoparticles to form multipurpose drug delivery systems [24,25].

Magnetic nanoparticles can be applied for physically directing of the drugs into their desired and accessible target cells or tissues by use of an external magnetic field[23]. Magnetic nanoparticles have attracted a special attention in nanomedicine due to advantages such as ideal surface modification, competency to move in cellular level by an external magnetic field and ability to hyperthermia effect[20,26]. Functionalization of these nanoparticles with molecular targeting agents improves their biomedical application especially in cancer therapy intentions.

The hollow structures of carbon nanotubes can be loaded with the drug molecules for extended release of the drugs [27,28]. Functionalization of single walled nanotubes by targeting agents has been used to selectively target of drugs by pH-dependent release profile [29].

Despite of many challenges, there is a great attention for the development of smart drug delivery systems. Smart drug

delivery systems based on polymeric nanoparticles may have extensive applications in oral drug delivery of biological drugs, which are sensitive to both gastric acid and enteric enzymes. Smart drug delivery systems can also be applied in the field of smart diagnostics [30].

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