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Role of Silicone-Based Nanodevices in Nanotheranostics

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Abstract

Nanoparticles are very tiny units with dimension measured in nanometers, employed in medical nanodevices to interact with cells and tissues, in order to perform specific tasks such as disease imaging, diagnostics and therapeutics. Moreover, nanodevices provide a good resolution image of the cells and tissues. Thus, they are very helpful in diagnosis and equally while performing surgeries. Among various classes of nanomaterials, silicon-based nanoparticles are referred as silicon nanocrystals are the most popular materials utilized in nanodevices for diagnostic and therapeutic purposes. With the fast improvement of silicon nanotechnology, silicon nanostructures/nanohybrids with alluring properties have been already produced for bioimaging and biosensing applications in biomedical field. Being employed in nanodevices, it is one of the recent advancements of nanomedicine. Silicone based nanodevices take advantage of silicone nanomaterial innovative capacities such as electronic, chemical, and optical properties so to be utilized in heterogeneous areas like monitoring, labelling, imaging, drug delivery, diagnostics, therapy, and surprisingly in nanosurgery and lab on chip techniques, etc., in order to improve health related problems more effectively and accurately.

Keywords

Nano-implements, Nanowires, Etching, Anti-inflammatory, Condensation, Biocompatible

1. Introduction

The importance of nanoparticles in medical devices is enormous as, they are nontoxic, immensely stable and biocompatible, moreover, they have the ability to act against biofilm formation [1, 2]. Normal bacterial activities such as cell differentiation, adhesion and replication can be interrupted by nanodevices made up of silica nanowires [3]. In addition, nano-implants are used for imaging such as oral pills contain very tiny cameras that can explore the body's internal parts [4]. Silicone based nanomaterial is also known as the porous nanoparticles which are synthesized by the electrochemical etching process of silicon wafer, whose size is generally from a few hundreds of nanometers to the several microns [5, 6]. While, silicon nanocrystals are synthesized by solid or gas state synthesis process [7].

1.1. Types of silicon-based nanodevices

There are mainly three types of silicon-based nanodevices in nanotheranostics applications namely: porous silicon nanoparticles [8], mesoporous silica nanoparticle [9] and periodic mesoporous silica nanoparticles [10].

1.1.1 Porous silicon nanoparticles

The bulk composition of porous silicon nanomaterials is pure silicon that is obtained through the process of etching of silicon wafers which is a top-down approach [11] and, as a result of sonication, nano-sized silicone particlesare obtained [12]. In the aqueous environment, these nanoparticles instinctively hydrolyzed into biocompatible silicic acid, whereas the surface contains hydrated amorphous silicon and silanol groups which make the surface functional through condensation by organ alkoxysilanes or by hydro-sialylation with the terminal alkynes [13, 14]. In the current research, functionalization of the porous silicon nanoparticle is done by adsorbing hydrophobic drugs, furthermore, encompassment of complex double emulsion microstructures is done [15, 16].

1.1.2 Mesoporous silica nanoparticles

The mesoporous silica nanoparticles also known as the MSN that helps in the drug delivery, because it offers certain advantages such as larger surface area, modification of the facile surface, and maintenance of uniform particle morphology [17, 18]. Mesoporous silica nanoparticles are synthesized by means of bottom-up approach either by hydrolysis or by alkoxysilane precursor condensation [19]. The templating surfactants for the adjustment of pore diameter and morphology is used while it is being synthesized [20]. The mesoporous silica nanoparticles are considered as an anti-inflammatory and anticancer drug transporter [21]. In delivery of two anti-tumor medicines, mesoporous silica nanoparticle-based nano-system have been proved versatile [22].

1.1.3 Periodic mesoporous organo-silica

These nanoparticles have been developed recently offering promising characteristics for biomedical applications. The organo-alkoxysilanes bridged are used to synthesis these nanoparticles, moreover, surfactant template synthesis is used to make it porous [23]. These nanoparticles have the advantage of the higher specific surface area and the pore interior is more hydrophobic as compare to the mesoporous silica nanomaterials [24]. In the current research, periodic mesoporous organo-silica is made that either has a magnetite or nano-diamond core with a bis-ethane; a silicon precursors shell [25]. The application of nano-diamond periodic mesoporous organo-silica nanomaterial is in the formulation of anti-cancerous drug (doxorubicin) [26]. Furthermore, it used in drug delivery and simultaneously for imaging [27]. The periodic mesoporous organo-silica nanomaterials are also used effectively for multiple theragnostic practices such as larger porous periodic mesoporous organo-silica nanomaterial with gold nanorods is used as loading and for delivery of small interfering RNA and DNA delivery in gene therapy [28]. Anothernovel nanomaterial namely hybrid mesoporous organo-silica nanoparticles with enhanced degradation ability is made that is utilized for the sonodynamic treatment of tumor [29].

1.2. Application of the silicon-based nanoparticles

The following are some applications of silicon-based nanoparticles:

- Nano-devices are used for making the miniature circuit element in nanoscale that replaced the conventional micro-electronics approaches such as silicon nanowires have been used to make-effect transistor logic gates and nanoscale switches [30].
- Semiconductor nanowire nanoelectronics has been fabricated to be used for cell interfacing, DNA, and protein delivery, biosensing (bio detection) and imaging [31, 32].
- Another application of nanotechnology is the design of silicon-based nano-sensors [33]. The detection of the optical property of porous silicon provides information about the concentration of the material or “species” which is bound to its surface [34].
- Silicon nanowires field effect transistors are applied for the direct real-time electronical detection of the biomolecule binding [35]. These are very sensitive due to the depletion or accumulation of charge carriers as result of the biological macromolecules binding to the surface of the silicon nanowires [36].

2. Conclusion

Thus, this silicone based nanodevices can change the areas of the genomics, proteomics, therapeutics systems and biomedical diagnosis. These devices can be used for the detection of biological macromolecules such DNA, proteinsand viruses etc.

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