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Silicon Nanoparticles Environment Protection and Health

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Abstract:
The industrialization and intense agricultural activities lead to the threat for environment and human health for both developing and developed countries. The remarkable developments in nanotechnology and nanomaterials play an important role for providing their potential benefits in almost every area of society. Nanomaterials of several kinds show diverse advantages in a variety of applications, from everyday goods such as polymers and cosmetics, to specialized technical applications in, for example, electronics, environmental safety systems and biomedicine. Nanomaterials because of there huge surface area and related high reactivity emerged as a new discipline with extensive applications in biology, medicine, pharmacology and remediations of environment pollutants. As a consequence of recent progression in biomedicine and nanotechnology, nanomedicine has emerged rapidly as a new discipline with extensive applications of nanomaterials in biology, medicine, and pharmacology. Among the various nanomaterials, silicon nanoparticles (SiNPs) are particularly promising in nanomedicine applications due to their large specific surface area, adjustable pore size, facile surface modification, and excellent biocompatibility. Nanotechnology is found to be one of the crucial future knowledge. This paper reviews the synthesis of SiNPs and their recent usage in drug delivery, biomedical imaging, photodynamic and photothermal therapy, and other applications. In addition, the possible adverse effects of SiNPs in nanomedicine applications are reviewed from reported in vitro and in vivo studies. Finally, the potential opportunities and challenges for the future use of SiNPs are discussed.

Keywords: Healthcare, nanoparticles, Environment, nanomaterials.

INTRODUCTION:

Nanotechnology has been considered as an applied technology in various areas in recent decades. Nanotechnology has been developed by a convergence of various sciences, providing the way to work at the atomic level and to create new structures (Mojtaba,2021). Nanotechnology works on the scale of nanometer (specifically, within the range of 1 to 100nm) to produce nanosized materials and devices with primarily new functions and properties by controlling the shape and the size of matter. The worldwide momentum of nanotechnology because of its promising applications which are encompassing several fields such as energy, medicine, and treatment of pollution that is offering leaping predictions in the transformation and improvement of conservation remediation approaches.

Silicon nanoparticles (SiNPs) also follow this trend and have a stable structure, large surface-to-volume ratio, high absorption quality, facile surface modification, adjustable pore structure, improved reactivity and robust delivery system than elemental system (Shalini.2019). Silicon nanoparticles (Si-NPs) are highly porous, biocompatible and possess a large surface area. Their primary applications include water purification and agricultural soil remediation, enhancing crop resilience against abiotic stress and in biomedicine for targeted drug delivery.

Health and Biomedical: Due to their non-toxic nature biocompatibility and large surface area, mesoporous silica nanoparticles are widely used in medicine as target nanocarriers for pharmaceuticals. The control the release rate of drugs, improving therapeutic efficacy while minimizing side effects.

FIBRICATION OF SILICON NANOPARTICLES:

Silicon stands as the second most abundant element on earth, surpassed only by oxygen. Its ample presence and cost-effectiveness has made it one of the most accessible inorganic materials available. Silicon nanoparticles have emerged as pivotal components in nanoscience and nanoengineering due to their inherent characteristics such as high energy capacity and outstanding optical properties. Numerous fabrication and characterization techniques have been researched so far, while a range of applications utilizing them have been developed.

Nanomaterials can be categorized in different ways. Foss Hansen et al. (2007) has developed a typology based on physical shape of the material. Three main categories are included bulk nanomaterials; materials that have a nanostructured surface and materials containing nanoparticles. This last category consists of the subcategories surface bound nanoparticles, nanoparticles suspended in the liquid, nanoparticles suspended in solids, and airborne nanoparticles (Foss, 2007). Since the first discovery of the unique optical properties of fluorescence silicon nanomaterials (Wilson, 1993, Park, 2001) numerous synthetic strategies have been reported to prepare silicon nanomaterials with high fluorescence and photostability, vastly facilitating the exploration of their optical applications in biochemical analysis (Atkins, 2011, Zhou, Yang, and Zhang, 2015, Dasog, 2016, Liu, 2016 and Xiaoyuan, 2018).

Biotechnological Applications: Nanotechnology has improved the medical subdivision with the amalgamation of nanomaterials for delivering drugs. The medications can be delivered to specific tissues with the help of nanomaterial (Kukkar, Vellingiri & Kaur; 2019). The inclusive consumptions of medicine and side effects are reduced expressively by organizing the medicines in the particular body parts in prerequisite doses. This approach reduces the costs and contiguous effects. The repairing and reproductions of spoiled tissue also known as tissue engineering can be accomplished by nanotechnology development. Nanotechnology has received keen interest in recent decades owing to its extensive use in several fields, including agriculture (Hasan; 2020).

Role of Silicon Nanoparticles in Environment and Agriculture:

Toxic heavy metals in air, soil, and water are global problems that are a growing threat to humanity. Effective methods to remove or reduce excess heavy metals in the living environments are being pursued all the time. With the rapid development of nanotechnology, nanomaterials are becoming widely applied in many industries due to their unique physiochemical properties such as small size and relatively large surface area, the latter which may allow nanomaterials to absorb some substances such as heavy metals. Lead (Pb) pollution primarily comes from cars, lead smelters, metal processing plants and incinerators, causing the pollution of drinking water and the atmosphere. Human exposure to drinking water and air containing an excess of Pb can lead to acute and chronic Pb poisoning, and breathing air, drinking water, eating food or swallowing or touching dirt that contains Pb can cause many health problems. In adults, Pb can increase blood pressure and cause infertility, nerve disorders and muscle and joint pain. Pb can also cause birth defects in unborn children. Therefore, worldwide government usually place an extra emphasis on measures to reduce Pb pollution.

Silicon Nanoparticles in Therapeutics and Drug Delivery:

Nanotechnology has improved the medical subdivision with the amalgamation of nanomaterials for delivering drugs. The medications can be delivered to specific tissues with the help of nanomaterials. The inclusive consumptions of medicine and side effects are reduced expressively by organizing the medicines in the particular body parts in prerequisite doses.

SiNPs has unique intrinsic properties of such as high surface area, large and tunable pore size, good biocompatibility and biodegradability, stable aqueous dispersion, photoluminescence, they have received much attention in the recent decades for their applications as a promising platform in the biomedicine field. These porous structures possess a pore size ranging from 2 to 50 nm which make them excellent candidates for various biomedical applications.
The ability to transport the therapeutic molecules to the specific site without any loss in their functions as well as structure is significant prerequisite for designing of an efficient carrier for targeting drug delivery. For achieving this objective, the carrier should be able to release the cargo molecules in a controlled manner. Compared with other porous material, silica-based nanoporous materials have been successfully investigated as an appropriate carrier for drug delivery, especially in the delivery of hydrophobic therapeutic agents due to attractive structural properties as mentioned above. Most of anticancer therapeutic agents have poor water solubility and belong to the class of hydrophobic drugs. Their low solubility in aqueous media is a critical obstacle for bioavailability of these drugs which can limit their administration via intravenous path. Therefore, it is a vital issue to improve the aqueous solubility of these therapeutic molecules without the use of organic solvents. Owing hydrophilic surface of nanostructured silicon becomes well distributed in aqueous solution. Besides, the high surface area/pore volume of they can provide compartmental reservoirs for multiple functionalities, which constitutes them as promising options for various medical imaging applications.

DIRECT IMPACT OF Si-NPs ON PLANTS:
The response of plants to nanoparticles depends on various factors, including the size, shape, method of application, chemical properties, and physical properties of the nanoparticles (Rastogi et al. 2017). Recent studies have shown that Si-NPs may directly interact with plants and impact their morphology and physiology in various ways, including the addition of structural color to the plants, and help in improving plant growth and yield (Bao-shan et al. 2004; Strout et al. 2013; Suriyaprabha 2014). Furthermore, SiNPs, due to their porous nature and capillary action, might serve in a similar way as nanozeolite that facilitates water retention, infiltration and soil aeration thus, improve the water holding capacity of the soil in arid environment.

CONCLUSION:
Nanotechnology is a promising area of interdisciplinary research that opens avenues in several fields, such as medicine, pharmaceuticals, electronics and agriculture. Nanoparticles have revolutionized the future approach for litigation of environment with biotechnology. At the nanoscale, silicon material (‚Si-NPs) properties are subject to many changes. This has advantages that can lead to good results, including the development of compatibility with the environment. Considering the advantages and various applications of nanostructured silicon., it can be used in global plans in various environmental areas such as controlling and reducing air pollution and management of wastes. These Si-NPs with the extraordinary advantageous including excellent structural properties, high drugs loading capacity, suitable biocompatibility, facility of functionalization, cost-effective preparation could be used clinically as promising nanostructures for diagnosis and treatment of various diseases. It has been presented that nanotechnology shows incredible characteristics for multifunctional, robust, and advanced therapeutic procedures which can improve treatment performance, pollution monitoring and agricultural improvements. Nanotechnology is a promising area of interdisciplinary research that opens avenues in several fields, such as medicines, pharmaceuticals, electronics and agriculture. Silicon nanoparticle- mediated targeting of biomolecules would be useful for developing new cultivars that are resistant to various biotic and abiotic factors. These nanoparticles can provide green and ecofriendly alternatives to various chemical fertilizers without harming nature. Thus, Si-NPs may have concrete solutions to many agricultural problems regarding weeds, pathogenicity, drought, crop yield and productivity.

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