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# A Brief Review on various applications of Nano-Silica and coated Nano-Silica

**Chandravadhana A[1*], NandaKumar V[2], Venkatramanan Kannan[3], Gladis Raja Malar C[4]**

[1,2,3]Department of Physics, SCSVMV Deemed University, Enathur, Kancheepuram, Tamil Nadu 631 561, India

[1]Department of Physics, S. A. Engineering College -Autonomous Chennai, Tamil Nadu 600 077, India

[2]Department of Physics, Government First Grade College for Women,

Holenarasipura Hassan District, Karnataka 573 211, India

[4]Department of Chemistry, Vel Tech Multitech Dr.Rangarajan Dr.Sakunthala Engineering College - Chennai,

Tamil Nadu- 600 062, India

**Abstract:** Nanoparticles are microscopic materials with unique physical and chemical characteristics due to their size, structure, biocompatibility, and large surface area, which have led to their widespread use in catalysis, medicinal applications, and other fields. Silica nanoparticles are the most stable of all the nanoparticles, are less poisonous, and can work with a wide range of chemicals and polymers. Because of their unique features and wide range of uses, silica-coated nanostructures pique researchers' curiosity. We provide a basic overview of the major uses of silica nanoparticles, as well as the developing applications of silica-coated metal nanoparticles, in this relevant study.

**Keywords:** Biocompatibility, Nonporous silica nanoparticles; Drug delivery; Gene delivery, silica coating

## 1. INTRODUCTION

Nano particles is defined as solid colloidal particles with a size range of 1 to 100nm [1]. Nanoparticles, which are invisible to the naked eye, can reveal a wide range of physical and chemical characteristics. It can be used in bio imaging applications because to the discrepancy in size and shape of nanoparticles [2]. The peculiar properties of these particles have attracted the curiosity of researchers in a variety of sectors, including electronics, health, and consumer items. Silica nanoparticles have recently seen a surge in use in agriculture, the food sector, and medicine delivery due to their advantages over ordinary nanoparticles. Silicon, such as fused quartz, fumed silica, and silica gel, is one of the most diverse families of manmade materials. Certain quartzite polymorphs show tetrahedral coordination [3]. Inorganic drug delivery technologies such as Gold nanoparticles, quantum dots, silica nanoparticles, iron oxide nanoparticles, and carbon nanotubes (CNT) have emerged as viable alternatives in a wide range of therapeutic applications in organic systems. Due to their particular features, Silica NPs play an integral role among these NPs. [4]. The outstanding Silica characteristics, as well as the improved use of metal NPs, piques researchers' attention. Metal NPs coated with silica are also becoming more common in catalytic and biological applications. M@SiO2 NPs have recently become a significant commercialization hurdle. Silica NPs are typically split into two types during nanoparticle synthesis: mesoporous and nanoporous. The size of the nanoparticles may be adjusted by adding surfactants [5]. Silica nanoparticles are frequently employed in a variety of applications due to their hydrophilic nature and varied characteristics [6, 7], Silica nanoparticles can be used as non-toxic DNA conjugation and drug delivery particles [8] published a study that looked at the use of nano-silica in the biomedical area. In the fields of biomedical and bioremediation, several reviews have been written [11], [9], [10], [12], for example, improved thermal stability and characteristics of silica-coated nanoparticles. [13] shown that doping TiO2 with SiO2 may create more advanced functional materials than single oxide alone. Furthermore, this coating allows for further functionalization and biocompatibility allowing for the use of nanomaterials in diagnostic and therapeutic procedures such as MRI [15].

## 2. SYNTHESIS AND CONTROL OF THE PROPERTIES OF SILICA NANOPARTICLES

Many attempts have been made to create silica NPs with precisely controlled physicochemical properties. The biggest requirement for silica Nanoparticles in biological applications is sufficient control of synthesis as shown in Fig 1.

### 2.1. Size control

The synthesis of size-controlled silica was initially described in 1968 [16]. In a procedure involving water, an alcoholic solvent, ammonia, and tetraalkoxysilane, monodisperse silica spheres with uniform diameters ranging from 50 nm to 2 nm were effectively generated. The reaction speeds and particle sizes of different alcoholic solvents and tetra alkoxysilanes, as well as the concentration of each component, were thoroughly examined [17, 18], as well as others explored the characteristics such as response and mechanism. To better size management for bigger NPs, a plan for distributed regrowth was devised [19, 20, 21] and demonstrated the fabrication of dye-doped silica NPs in a reverse micro emulsion with perpetually tuneable sizes and their use to cellular contrast imaging. [22] employed the reverse micro emulsion approach to create core-shell structures by covering other functional NPs with silica.

### 2.2. Shape control

This superficial shape manipulation of silica NPs is critical for important research, the shape influence of nanomedicine in a biological system, and enhancing the shape of nanomedicine for value-added diagnostics and therapy. Only a few methods for creating one-dimensional silica nanorods/nanotubes have been documented, despite the fact that there are various ways to make size-controlled silica nanospheres [23, 24, and 25]. Silica nanotubes may be manufactured using a variety of templates, including anodic aluminium oxide membranes [26].

### 2.3. Surface property control

To summarise, the surface features of NPs play a significant role in the interactions between NPs and biological systems. As a result, modulating the surface qualities of any nanomedicine is critical for effective disease targeting and enhanced therapy. Using silane chemistry, either by physical adsorption or covalent conjugation. Surface alteration is an advantage of silica NP. Modulating the surface property of silica NPs allowed them to have a positive, negative, or zwitterion surface charge [27, 28];

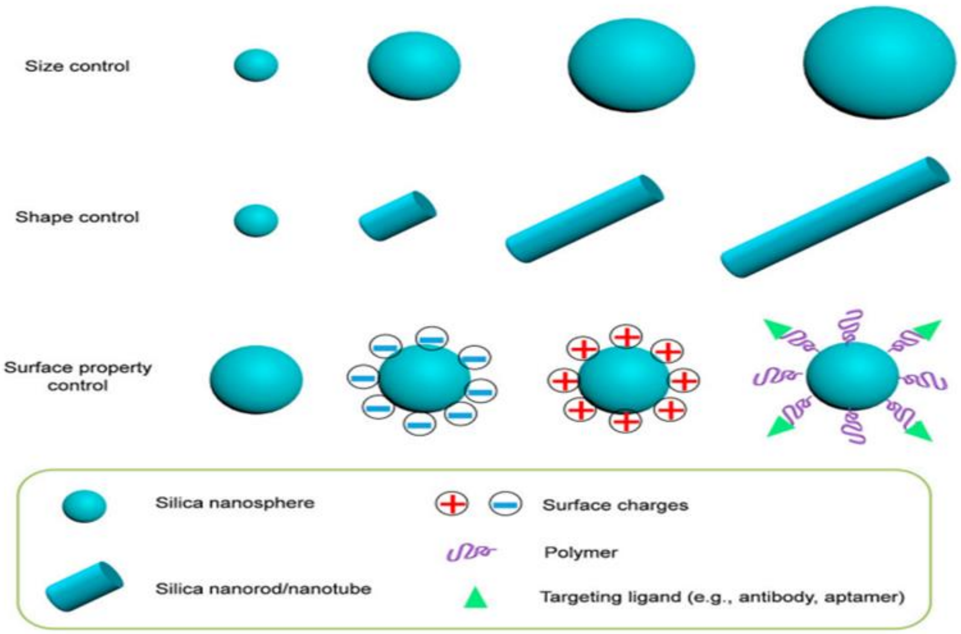


**Figure 1. Controlled physicochemical characteristics of silica nanoparticles are depicted in this diagram [5].**

## 3. SILICA COATING

The week surface attachment was further enhanced by exploiting the pioneering silica-coating of citrate-reduced gold nanoparticles, which began with the growth of silica nanoparticles in basic aqueous solution. Later, thicker silica shells can be produced on surface-stabilized gold nanoparticles by hydrolysis/condensation of tetraethyl orthosilicate (TEOS), a typical precursor of silicon alkoxides [29].

To achieve efficient surface-coating, it is necessary to take advantage of the surface chemistries and interface characteristics of metal nanoparticles, as illustrated in fig, 2. Small molecules, synthetic polymers, and biopolymers are used to create metal nanoparticles with favourable surface groups for subsequent silica deposition.

Silica-coating of citrate-capped cobalt nanoparticles was reported by [30] [31] used the Stober process to interface hydrophobic metal nanoparticles with ligand-exchange followed by silica growth in the surface adsorption of methoxy poly(ethylene glycol) silane to replace oleylamine on silver nanoparticles, which is then subjected to further hydrolysis/polycondensation to form thin silica layer-stabilized silver nanoparticles followed by thick silica coating.

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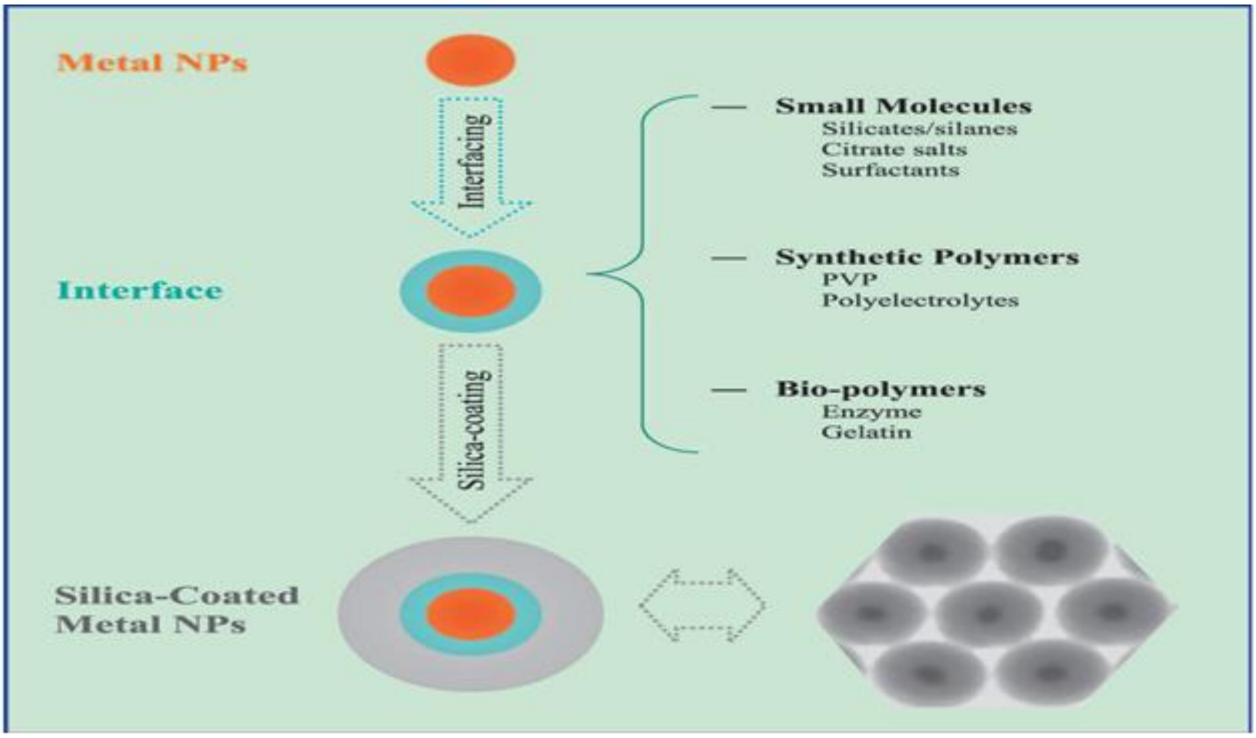
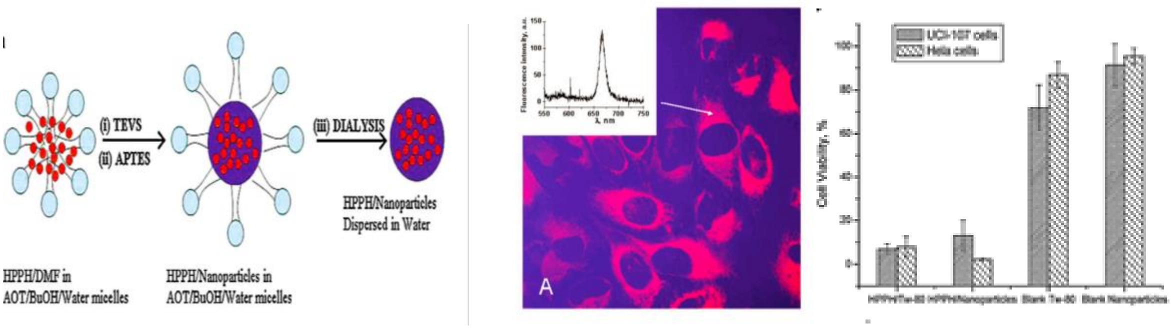



**Figure 2. Silica-coating techniques Liu et al., 2010 [32]**

## 4. SILICA NANOPARTICLES AND SILICA COATED NANOPARTICLES IN BIOMEDICAL APPLICATIONS

Nanoparticles can detect even tiny bio molecules due to their small size and great surface area to volume ratio. Due of their lower toxicity, silica nanoparticles are more important for bio imaging than quantum dots [33, 34] Obesity can be treated using silicon nanoparticles as well [30] .Nanoparticles have shown to be extremely effective in cancer screening, diabetes therapy, infection treatment, and a variety of other applications[35], [28]. Nano–objects containing photosensitizers effectively destroyed cancer cells. For the application of lung infection[36] employs biodegradable nanoparticles [37] reformulate Clofazimine (CLZ) as an antibiotic in TB infections in nanoporous silica particles. As a result, in the future, silica nanoparticles might be beneficial antibacterial agents that are also less harmful. Silica NPs have been combined with a wide range of chemicals, including small molecule medications, photosensitizers for photodynamic therapy (PDT), proteins, peptides, DNAs, and RNAs, to treat diseases such as cancer and heart disease[38, 39] [40]. The behaviour of cancer cells and their annihilation by photodynamic action have been explored using 30-nm silica NPs captured with the water-insoluble photosensitizing anticancer medication 2- devinyl-2-(1-hexyloxyethyl) pyropheophorbide (fig,3a—c). [41].




(a) (b) (c)

**Figure 3. Photodynamic treatment with silica nanoparticles (NPs). (a—c) Photosensitizing anticancer drug embedded in silica nanoparticles. (a) Scheme depicting the synthesis and purification of HPPH-doped silica-based N in a micellar medium. (b) Confocal fluorescence image of HeLa cells treated with HPPH-doped silica NPs. Transmission (blue) and fluorescence (red) channels are shown. Inset: Localized fluorescence spectra from**

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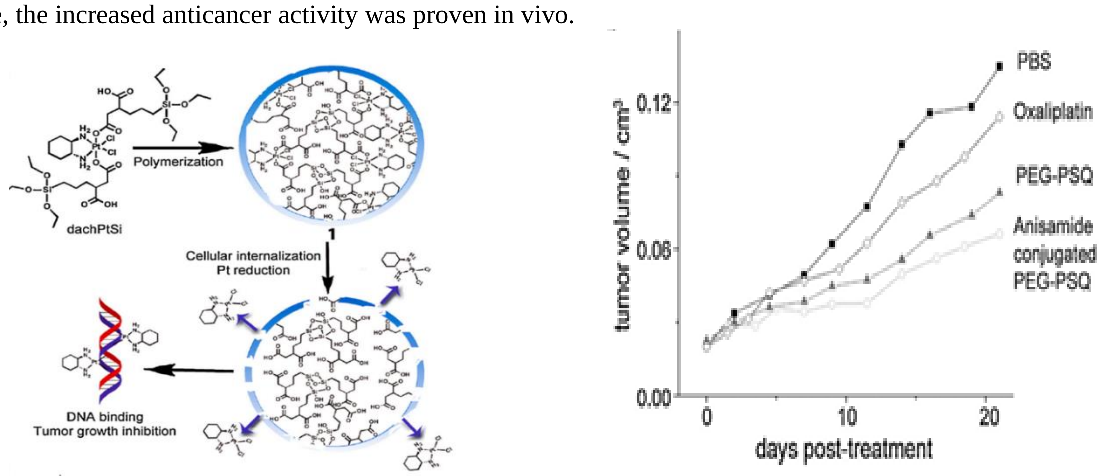
**the cytoplasm of the treated cell. Excitation is at 532 nm. (c) Percentage of cell survival of UCI-107 and Hela cells, after treatment with various samples and subsequent irradiation with 650 nm lasers light (with reference to irradiated but untreated cells as having 100% survival). Cell viability was assayed by the MTT method (values: mean ± standard deviation) [41].**

Novel conjugation ways to integrate small-molecule anticancer medicines onto silica NP have recently evolved utilising silane chemistry [42], reported on the development of bridging polysilsesquioxane nanoparticles for the delivery of oxaliplatin. They started by making a bis(trialkoxysilanes) monomer using a Pt(IV) complex, which they subsequently hydrolyzed and condensed to make polysilsesquioxane NPs in an anionic reverse micro emulsion system using base-catalyzed sol-gel polymerization. In comparison to other known nanoparticle platforms that carry Pt (IV) prodrugs, drug loading capacity was reached (35—47 percent by weight). In healthy conditions, endogenous biomolecules such as glutathione and cysteine may rapidly reduce the Pt (IV) prodrug in polysilsesquioxane NPs to release the active Pt (II) complex and fix DNA fig. 4.. In an AsPC-1 pancreatic subcutaneous xenograft tumour model in mice, the increased anticancer activity was proven in vivo.




(a) (b)

**Figure 4: Targeted platin-based cancer treatment with polysilsesquioxane nanoparticles (PSQ). (a) Illustration of the production of polysilsesquioxane nanoparticles (PSQ) from the Pt (IV) precursor dachPtSi. The Pt(IV) complexes in PSQ will be decreased upon cellular internalisation and interaction with endogenous biomolecules, releasing the active Pt(II) agent. (b) Curves of tumour growth inhibition. On days 0, 7, and 14, mice were given 5 mg Pt/kg against an AsPC-1 subcutaneous mouse xenograft [42].**

Metal-coated Si NPs have been explored for photothermal cancer treatment near IR light adsorbing NMs[43]. For bio-detection, Ag@SiO2 nanoprobes have been developed. , Bio-detection applications experiments using thin silica shell–coated tiny gold NPs were similar[44]. Cd SeS QDs/ SiO2 have been widely researched for biomedical applications such as live cell imaging with Si coating[45]. Controlling the thickness of the Si coating, as reported by [46], results in high levels of photodynamic reactivity, which is employed in cancer therapy[47], studied the reduction of photocatalytic activity of Titania nanoparticles covered with Si. [48].

## 5. GENE DELIVERY

Gene delivery is another important use of silica nanoparticles, in addition to the transport of small chemicals and proteins. One prominent example is the use of silica NPs for gene transfer due to their surface modification with cationic compounds. Furthermore, due to features such as bio-inertness and less toxicity than some cationic polymers used for gene transport, Under physiological conditions, silica NPs are more stable than liposomes and other self-assembly nanostructures.

## 6. APPLICATION OF SILICA NANOPARTICLES IN AGRICULTURE

Reduced yields in agriculture are caused by a variety of factors including fungus, weeds, and insects. Chemical pesticides may pose a risk to human health and the environment. As a result, in the present setup, environmentally friendly pesticides are the major emphasis. Mesoporous Silica nanoparticles are used in plant biotechnology to deliver proteins, nucleotides, and compounds [49] to protect maize seedlings from fungal infection[50], investigated the

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increase in germination rate. The use of Silica nanoparticles increases the plant's ability to absorb water [51]. The use of Silica Nanoparticles has been seen to increase the strength and structural stiffness of the plants [52].

## 7. APPLICATION OF SILICA NANOPARTICLES IN FRUIT PRESERVATION INDUSTRY

Silica NPs combined with other biodegradable polymers are currently being utilised to replace polythene bags and plastic materials, which have become a serious environmental threat. Nanomaterials play an important role in guaranteeing the safety of food [53]. Loquat fruit wrapped with chitosan/nano – Silica hybrid films enhances shelf life and decreases sugars by including enzymes such as catalase, superoxide dismutase, and ascorbate peroxidase [54] . Fruit that has been preserved with a nano–silica hybrid coating has a longer shelf life [55].

## 8. APPLICATION OF SILICA NANOPARTICLES IN INDUSTRIAL APPLICATIONS

Nano-Silica combined with polyethylene glycol is used to improve oil recovery. As a hydrophilic agent, chains are used, and propyl chains are used as a hydrophobic agent [56] Silica Nanoparticles' usefulness in the oil sector has resulted in increased oil recovery [57]. The use of nano-silica in the determination of rhodamine B (RhB) [58]

## 9. APPLICATION OF SILICA NANOPARTICLES IN WATER PURIFICATION

Silica NPs should be used to remediate methyl red dye, which is damaging to the eyes, digestive tract, and skin [59]. The use of nano–silica synthesised with silver NPs as an absorbent for dye removal, water disinfection, and bio fouling control was successful.

## CONCLUSION

This review study summarises the current state of knowledge about the use of Nano – silica and silica-coated nanoparticles. Because of its unique qualities, such as huge surface area, size and form, and excellent biocompatibility, nano silica has been produced. Nano silica is a fascinating shot because of its many contributions in the biomedical area, agriculture, and the food business. Apart from nanotechnology, nano silica has appeared in a variety of disciplines of science and engineering. Important uses in cancer treatment include diagnostics, imaging agents, and targeted medication administration. Nano silica has a number of notable attributes, one of which is that it is less harmful to the environment. It may also be used as herbicides, water purification, and bioremediation of contaminants in the environment. Nonporous silica NPs have a wide range of medicinal uses, including medication administration, protein and gene transport, and molecular imaging. Similarly, high-quality synthesis of dense and porous silica-coated nanostructures, especially for catalytic, colorimetric diagnostics, photothermal therapy, surface-enhanced Raman scattering (SERS) detection, and other applications, quenches interest in research. Various nanoparticles containing coated silica have been achieved in the laboratory, but commercialisation remains a major hurdle. Multifunctional silica-coated optical, electrical, and magnetic nanostructures are temporarily providing new prospects for creative applications.

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