

SYNTHESIS OF SILICON QUANTUM DOTS AS BIOCOMPATIBLE NANOPROBES FOR BIOMEDICAL IMAGING AND DIAGNOSTICS

Zufarov Asliddin Mirzabaevich

Zarmed University , Samarkand campus

Abstract: *This of the research purpose in medicine biomedical to describe and diagnosis for suitable was silicon quantum points synthesis and their physicochemical characteristics from evaluation consists of. Silicon quantum points at low temperature bottom-up and sol -gel synthesis in the way synthesis and their the surface biocompatibility increase for the purpose modification was done . Obtained quantum points physicochemical characteristics studied . Obtained from the results known, silicon quantum points biological in the environment sustainable , biomedical to describe and diagnostics systems for safe and promising nanoprobables as application possible .*

Key words: *Silicon quantum dots, biocompatibility, biomedical imaging, nanoprobables, fluorescence, surface functionalization, diagnostics*

Introduction

In the latest modern biomedicine, the issue of early detection and accurate diagnosis of diseases is one of the urgent scientific problems. In the words of the famous physicist R. Feynman, “There is plenty of room at the bottom” the control of matter at the nanoscale will lead to a fundamental revolution in science[1]. Silicon quantum dots exhibit strong photoluminescence, while avoiding the toxicity problems associated with cadmium-based quantum dots, which makes them promising candidates for biological imaging[2].

Nobel Prize Prize winner A. Ekimov by quantum points phenomenon discovery to be and nanoscale semiconductor of materials unique optical features open gave and their biomedical to be used road opened.

In recent years, quantum dots have been widely used in biomedical imaging as fluorescent markers due to their high optical and photostability. Silicon quantum dots have the advantage of being less toxic and more bioavailable than other quantum dots. They are also considered as effective nanomaterials for bioimaging and early diagnosis due to their biodegradability in biological media.

Such silicon quantum points synthesis, surface sustainability, biological systems with mutual impact still complete unexplored. This in the article synthesis methods, surface modification and their optical properties with related problems studied.

This research will provide opportunities for researchers working in the fields of biomedicine, medical physics, and diagnostics, as well as for specialists involved in clinical imaging medical technologies.

MATERIALS AND METHODS

Silicon quantum dots are semiconductor nanomaterials. Their optical properties due to the quantum confinement effect, which changes the energy bands, and strong

photoluminescence occurs. Strong photoluminescence allows them to be used in bioimaging as highly sensitive nanoprobe, that is, very small probes that can detect a specific molecule entering the cell and giving a signal.

Optical efficiency is not only related to the biological adaptability and stability. We have visualized *in vivo* using silicon quantum dots, which provides real-time visualization of biological processes in organisms. Their excellent optical properties and surface functionality for targeted delivery make quantum dots valuable tools for studying molecular events, disease progression, and response to treatment in preclinical models. The physicochemical properties of quantum dots have enabled their applications in diverse fields such as single-electron transistors, solar cells, LEDs, displays, lasers, photodetectors, photocatalysts, photovoltaic devices, quantum computing, forensics, microscopy, and medicine[3].

Silicon quantum points biological in the environment decomposed, organism for relatively harmless was orthosilicate acid harvest does.

Silicon quantum points mainly sol-gel method through synthesis low temperature during processing under the circumstances inorganic and half inorganic nanomaterials to take opportunity the sol-gel process advantage from that consists of synthesis in the process particles size and surface properties control to do possible. Sol-gel method through taken silicone quantum points medicine carrier systems and fluorescence nanoprobe in creation especially it is convenient because their surface chemistry biological molecules with easy Silicone quantum points in the context of sol-gel method silicon reasonable from precursors, in particular tetraethoxysilane (TEOS) or other organosilane from compounds to use opportunity this gives biological application for necessary low toxicity and high cleanliness provides.

In the process of synthesis, the silicon precursor tetraethoxysilane (98%, Jiangxi, China), ethanol (96.4%), the surfactant polyethylene glycol-6000 (Jiangxi, China) and TiCl_4 , Al_2O_3 of the chemically pure qualification were used as templates.

The most suitable for biomedical purposes is tetraethoxysilane (TEOS, $\text{Si}(\text{OC}_2\text{H}_5)_4$). Solvents were ethanol ($\text{C}_2\text{H}_5\text{OH}$), distilled water. Catalysts. Acid catalysts were hydrochloric acid (HCl), acetic acid (CH_3COOH). Alkaline catalysts were ammonia solution (NH_4OH), reducing agents were ascorbic acid, 3-aminopropyltriethoxysilane $-\text{NH}_2$ to increase the biocompatibility of the nanoparticle, and surface stabilizers were polyethylene glycol (PEG), polyvinylpyrrolidone (PVP). Ethyl acetate, phosphate buffer solutions were used for purification and precipitation of additional substances[4].

During the synthesis, several samples were obtained based on TEOS: $\text{C}_2\text{H}_5\text{OH}$: H_2O : HCl = 1: 5: 5: 0.02 mol at temperatures of 30°C and 60°C . 10 ml of alcohol solution of PEG was added to distilled water and stirred for 30 minutes until the mixture became homogeneous. To activate chemical reactions during the synthesis, HCl solution was added to the mixture with stirring until $\text{pH} = 2$. TEOS dissolved in ethyl alcohol was added dropwise to the resulting solution for 10 minutes. To ensure the stability of the resulting nanoparticles, 0.75 mol of polyethylene glycol was added to the solution[5]. The colloidal solution was carried out in a nitrogen atmosphere. The physicochemical properties of the obtained samples were studied.

SiO₂ based on silicon quantum points synthesis the scheme in Figure 1 below according to done increased.

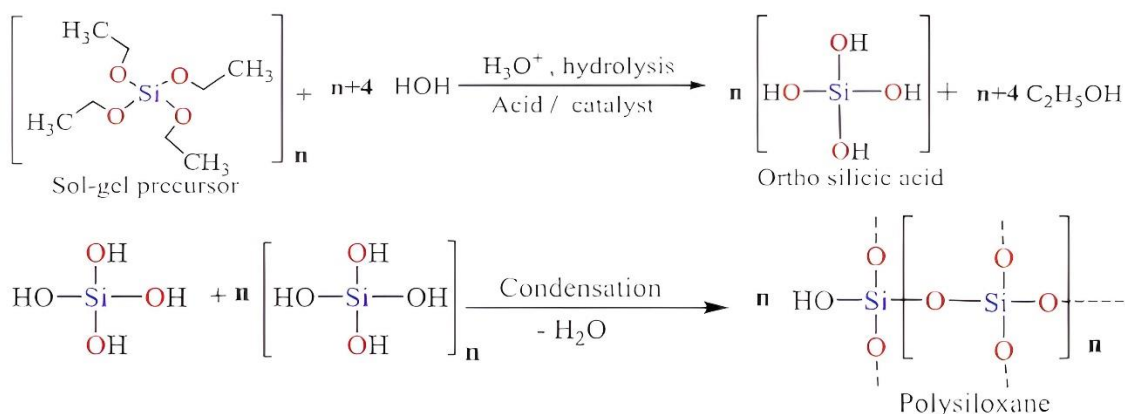


Figure 1. In the sol–gel process polysiloxane network formation

RESULTS AND DISCUSSION

Stabilized silicon quantum dots with hydrophilic group stabilizers have a significant effect on the size and optical properties of silicon quantum dots. The absorption and luminescence spectra of silicon quantum dots stabilized with hydrophilic group retained polyethylene glycol were presented. The maximum peak of the luminescence spectra was found to be at 570 nm and the absorption spectra were found to be at 380 nm. The absorption spectra showed strong adsorption in the range of 350-450 nm. The adsorption shifted to shorter wavelengths, indicating that the silicon quantum dots are small in size.

The photoluminescence spectra of the silicon quantum dots show strong and stable luminescence with a luminescence maximum at 580 nm. These maxima indicate that they are suitable for biomedical imaging. These results were obtained on a Shimadzu RF 6000 Spectro Fluorophotometer (Figure 2).

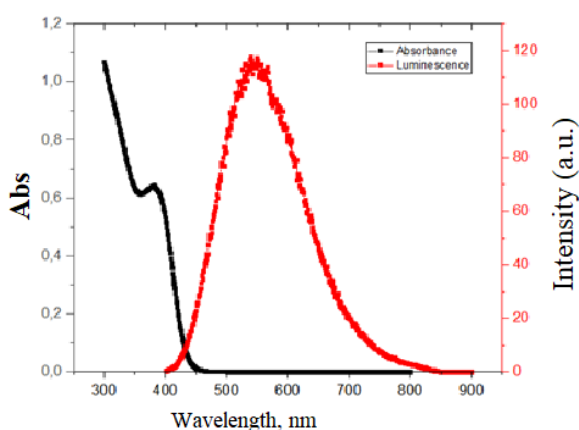


Figure 2. Absorption and luminescence spectra of silicon quantum dots stabilized with polyethylene glycol stabilizer



The broad peak observed at $2\theta = 28.4^\circ$ in the XRD diffraction spectrum corresponds to the (111) plane of Si. The width of the peaks confirms that the Si quantum dots are nanometer-sized. These results indicate that the Si QDs have a crystal structure (Figure 3).

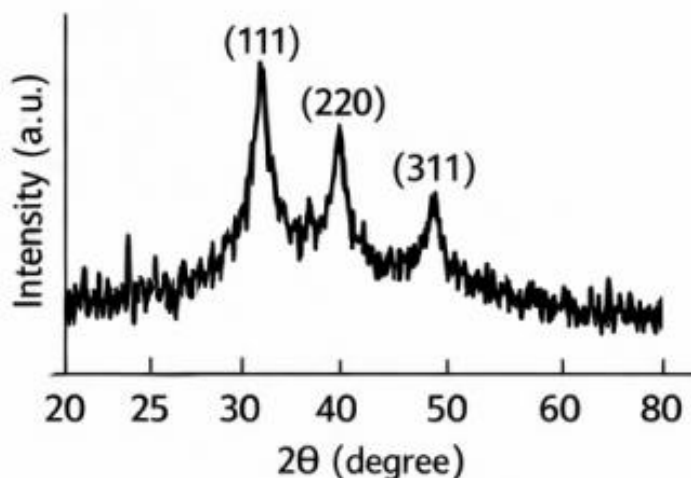


Figure 3. Silicon quantum dot X-ray diffractogram

The infrared spectra contain the 3200-3600 cm^{-1} region –OH, –CH₃ group 2960 and 2870, –COOH 1800-1740 cm^{-1} , –CH (alkane) 2850-2960 cm^{-1} , C=O (carbonyl) 1700-1750 cm^{-1} , C–O (esters, alcohols) 1050-1150 cm^{-1} , which also corresponds to Si–O–Si, and it can be concluded that these groups are present in the compound (Figure 4).

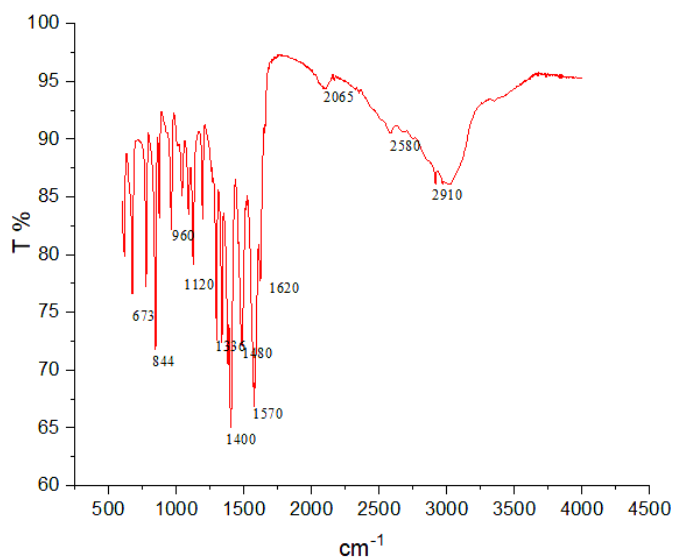


Figure 4. IR spectrum of silicon quantum dots

Silicon quantum dots are used as effective markers for imaging cells and tissues due to their high quantum efficiency and wide range of spectral range properties. When they enter cells, silicon quantum dots emit ultraviolet (UV) or visible light in different colors (Figure 5).

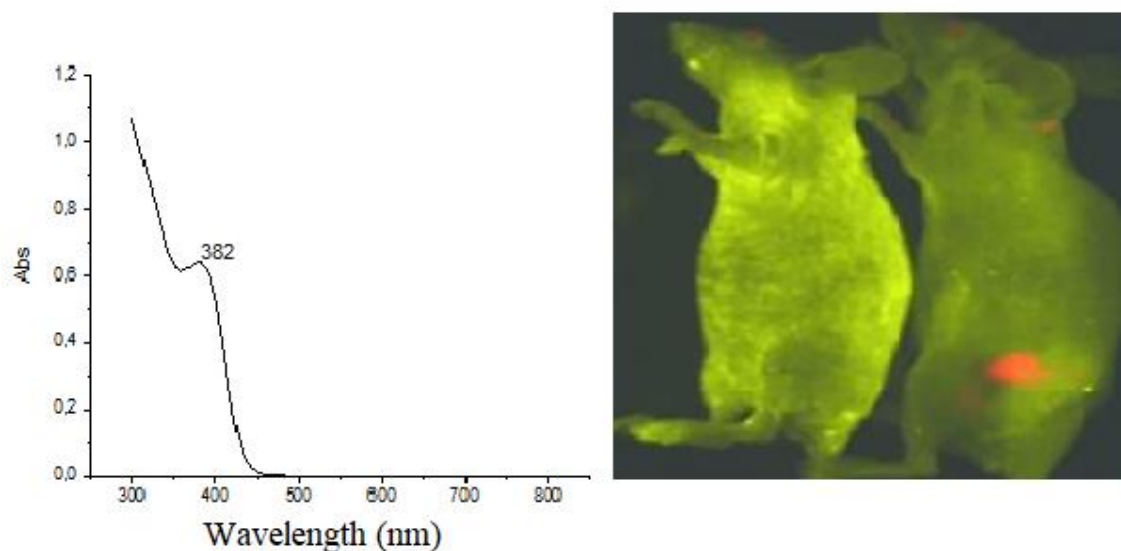


Figure 5. Absorption spectra of a sample taken from rat blood plasma

In rats, the image of the quantum dot in ultraviolet light was studied with silicon quantum dots fed into the rat's body (the experiment was conducted in the vivarium laboratory of the Institute of Biochemistry of Samarkand State University).

Conclusion

In this study, the synthesis of effective biocompatible silicon quantum dots for bioimaging and diagnostics was carried out, as well as their physicochemical characteristics were studied. During the synthesis process, it was possible to obtain silicon quantum dots that are well dispersed in water, stable and have strong photoluminescence. As a result of studying the optical properties, it was found that silicon quantum dots have strong absorption in the ultraviolet region at 380 nm and photoluminescence maxima around 570 nm. This is explained by the effective stabilization of the surface of the quantum dot. XRD analysis proves that silicon quantum dots have a nanocrystalline structure, and the IR spectra contain Si-O-Si, O-H and Si-H functional groups.

The results of this study will provide a solid basis for the production of biocompatible silicon quantum dots and their application in the fields of bioimaging and diagnostics.

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