ACADEMIA ROMÂNĂ
Revue Roumaine de Chimie
http://web.icf.ro/rrch/

Rev. Roum. Chim.,
2018, *63*(1), 55-58

THE FORMATION OF SILICA NANOWIRES USING GREEN BEANS

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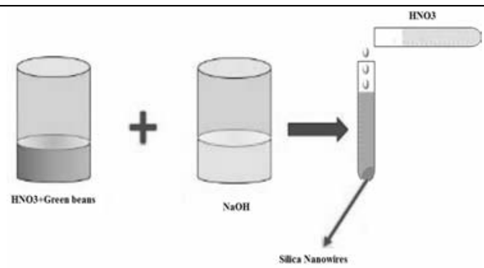
Received March 27, 2017

In this work, we develop a simple method to synthesize silica nanowires using green beans. UV–vis absorption spectra, dynamic light scattering (DLS) and transmission electron microscopy (TEM) have been used to trace the growth process and elucidate the structure of the silica nanowires. The UV–Vis absorption spectrum of solutions showed a surface plasmon resonance absorption bands about 346 nm and 374 nm. Also, we obtain silica nanowires of an average diameter of 25 nm after separation and washing procedures.



INTRODUCTION

Various methods for the preparation of nanoparticles are employed such as plasma synthesis, chemical vapour deposition, micro emulsion processing, combustion synthesis, sol-gel processing, hydrothermal techniques etc. Recent efforts for the preparation of nanoparticles are focused on size control, morphology and surface reactivity of nanoparticles.[1-3] Silica nanoparticles are frequently used nanomaterials in a variety of technological applications such as industrial manufacturing, packaging, composite and ceramics materials, drug delivery, adsorption, bio sensing and catalytic applications.[4,5] The great interest shown to nanoparticles is attributed to their large surface area to volume ratio, low toxicity, high chemical and physical stability, and straightforward surface chemistry, which allows them to be combined or functionalized with a variety of functional species or molecules.[6,7] There is a greater need to develop reliable, green and ecofriendly efficient methods for the synthesis of nanoparticles. Researchers in the field of nanotechnology have been looking at biological systems for toxic-free synthesis of nanoparticles. Green synthesis of nanoparticles is an emerging field of nanotechnology, which attracts great attention in the fields of medicine, pharmaceutical, electrical, technological and other science research areas.[8,9] Mostly the nanoparticles synthesized through different chemical and physical methods, these approaches are complicated, expensive and cause potential environmental and biological hazards. Green synthesis of nanoparticles with the help of plants as reducing agents is an efficient, cost effective, fast and eco-friendly in nature. In recent past, an increased number of scientists adopted green synthesis methods for the production of a narrow range of different types of nanoparticles like calcium, copper, gold, iron, silicon, silver and zinc from different medicinal plants.[10,11]

Green beans are the unripe fruit and protective pods of various cultivars of the common bean. Immature pods of the runner bean, yardlong bean, and hyancinth bean are used in a similar way. They are distinguished from the many differing varieties of beans in that green beans are harvested and consumed with their enclosing pods, typically before the seeds inside have fully matured. This practice is analogous to the harvesting of unripened pea pods as snow peas or sugar snap peas. In addition, green beans contain high amount of silica. We herein

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describe an easy synthetic route for silica nanowires by green beans as silica source. Then the nanowires were characterized by various techniques.

RESULTS AND DISCUSSION

Before the synthesis, green beans were mixed with nitric acid (1M HNO_3) to remove the organic part like cellulose and lignin materials. The liquid fraction was discarded and the solid residue containing SiO_2 was washed several times with distilled water. The content was stirred with 1M NaOH to form hydrated sodium silicate. The mixture was titrated with 3M HNO_3 to obtain a pure form of SiO_2, Sodium nitrate and water molecules.

$$\text{Green beans} + HNO_3 \longrightarrow \text{Liquid fraction} + SiO_2 \quad \text{(solution 1)}$$
$$2NaOH + SiO_2 \longrightarrow Na_2SiO_3 + H_2O \quad \text{(solution 2)}$$
$$Na_2SiO_3 + 2HNO_3 \longrightarrow SiO_2 + 2NaNO_3 + H_2O$$

The preliminary evidence for confirmation of synthesized nanoparticles was solution colour change after synthesis. The absorption band at about 340-380 nm is known to be due to surface plasmon resonance in silica nanoparticles. In fact, the energy of absorption would depend on the degree of plasmon resonance. The UV–Visible spectrum of the solution 1 showed a well-defined surface plasmon resonance at ~346 nm (Fig. 1a). The technique outlined above has proven to be very useful for analyzing nanoparticles [12]. Also, The UV–Visible spectrum of the solution 2 showed a maximum wavelength at ~374 nm (Fig. 1b). It is seen that the maximum wavelength has been shifted from 346 to 374 nm. It seems the peak shifting to 374 nm is the result of change in the amount of green beans powder and increasing silica concentration. In fact, second peak is due to interparticle dipole-dipole couplings of silica nanoparticles. The aggregation of silica nanoparticles during synthesis lead to the formation of silica nanowires. Dynamic light scattering is a used method for the determination of nanoparticle size. The size distribution of silica nanoparticles (solution 1) shows that the nanoparticles size is 25± 10 nm (Fig. 2).

TEM micrograph of silica colloidal nanoparticles (solution 1) is shown in Fig. 3 that confirms DLS analysis. Also, TEM micrograph of solution 2 shows nanowires formation (Fig. 4) that confirms UV-Vis spectroscopy. In addition, the average diameter of nanowires was measured about 25 nm by TEM. The formation of nanowire shapes can be attributed to both the Ostwald ripening at the expense of small silica nanoparticles and to the deposition of newly formed silica. Increasing silica concentration may lead to the aggregation of silica nanoparticles that show a tendency to undergo fusion into wire-like structures.

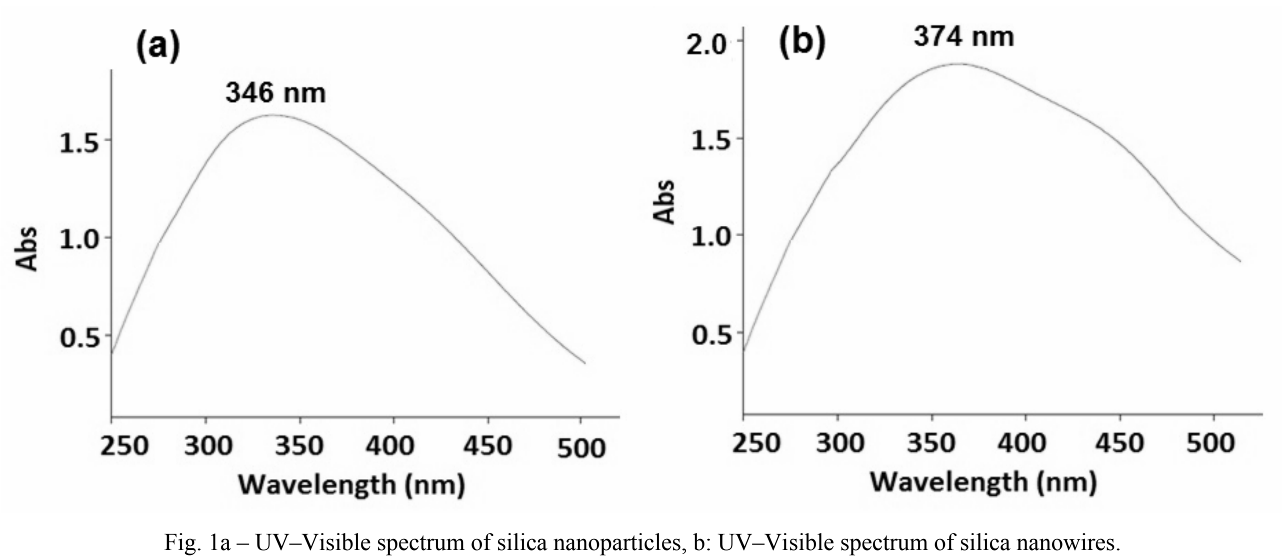

Fig. 1a – UV–Visible spectrum of silica nanoparticles, b: UV–Visible spectrum of silica nanowires.

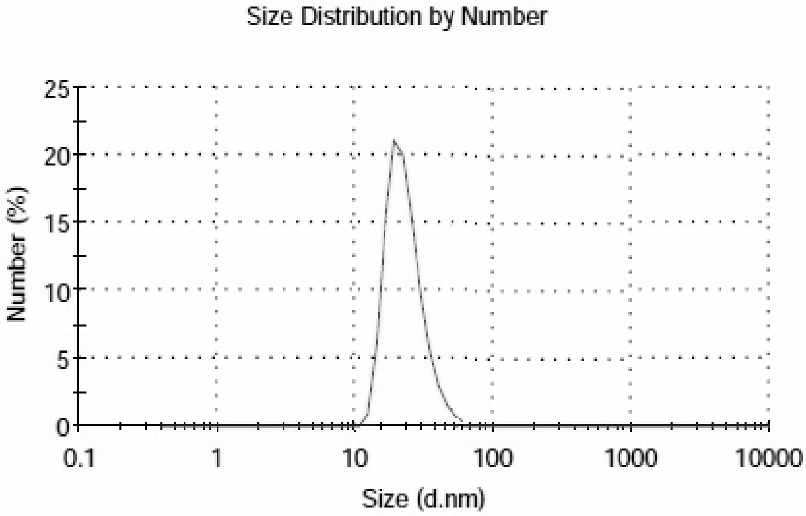

Fig. 2 – A particle size distribution histogram of silica nanoparticles.

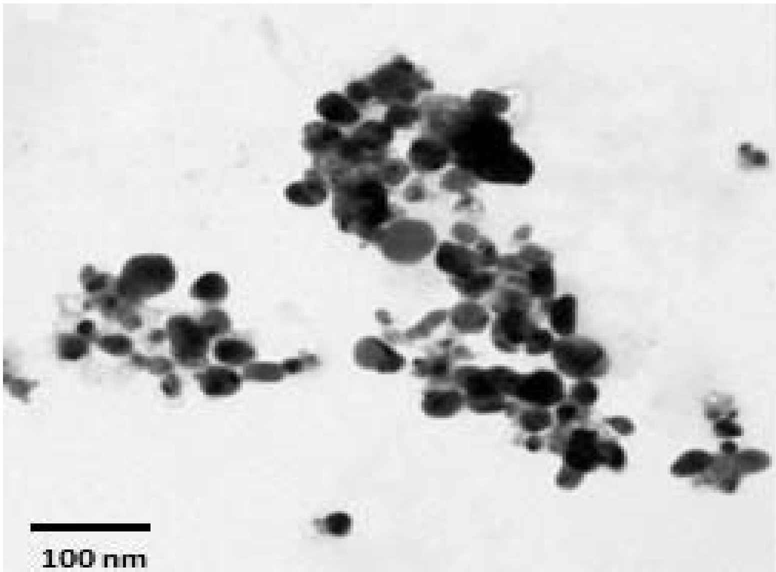

Fig. 3 – TEM micrograph of silica nanoparticles.

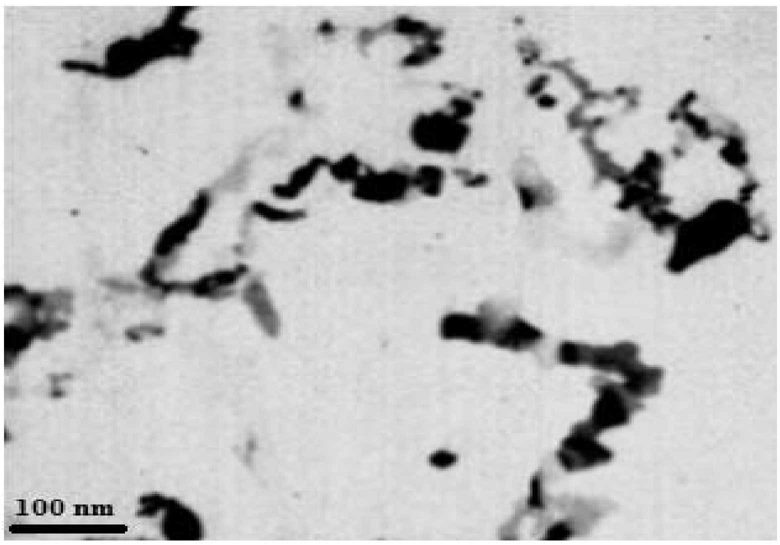

Fig. 4 – TEM micrograph of silica nanowires.

Fig. 5 – Green beans.

EXPERIMENTAL

Healthy green beans are collected from near and surrounding places of Garmsar city, Iran (Fig. 5). The silica nanoparticles were synthesized by a method similar with Adam procedure.[13] The collected green beans are washed 2-3 times with running distillate water and dried up to 1 day under sterile conditions. The 10 g of green beans powder was taken in 500 mL of flask, stirred for 24 h with 250 mL of 1M HNO_3 (called solution 1). The content was filtered and washed with distilled water. Now this solution was dried in an oven at 100°C for 1 day. This solution was stirred with 250 mL of 1M NaOH solution up to 24 h in a magnetic stirrer. The obtained reaction mixture was separated with suction pump and titrated with 3M HNO3 to decrease the pH between 8 to 9. The contents were centrifuged at 5000 rpm for 15 min to separate biological compounds. The contents were washed 3 times with distilled water and dried at 60°C in an oven for 1 day. The obtained powder was characterized by UV–Vis spectroscopy from PerkinElmer Company, model Lambda25, USA, and transmission electron microscopy (TEM) from Zeiss Company, model EM900, Germany. Distribution of the particles of various sizes was determined using dynamic light scattering (DLS) from malvern Company, model Nano ZS (red badge) ZEN 3600, UK. In addition, this procedure was repeated for 20 g of green beans powder (called solution 2).

CONCLUSIONS

Colloidal silica nanowires were synthesized using green beans as silica source.

The formation of the nanowires takes place by the aggregation of silica nanoparticles initially formed in during the synthesis procedure.

UV–Vis spectroscopy put in evidence both the presence of nanoparticles, as well as of the nanowires, during the different synthesis steps.

Transmission electron microscopy (TEM) confirmed the UV-Vis result regarding the formation of nanowires with diameters of about 25 nm.

From a technological point of view, these obtained silica nanowires have potential applications in various fields and this simple procedure has several advantages such as cost effectiveness and scale commercial production.

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