# CHAPTER 2

# BIOSYNTHESIS OF SILICA NANOPARTICLES (SI-NPS) FROM WHEAT HUSK FOR ARSENIC HEAVY METAL REMOVAL FOR BIOMEDICAL APPLICATIONS

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## 2.1 INTRODUCTION

Arsenic contamination of soil and water is a critical global public health concern that has been linked to a variety of adverse health effects, including skin lesions, cardiovascular disease, diabetes, and neurological disorders [1]. The World Health Organization (WHO) has set the utmost allowable arsenic concentration in drinking water at 10 g/L [2]. However, many regions across the globe exceed this threshold, necessitating the development of efficient remediation strategies. In recent years, nanotechnology-based methods have emerged as promising alternatives for addressing soil and water contamination by arsenic. Particularly, silica nanoparticles have demonstrated remarkable potential as effective arsenic adsorbents. Their exceptional physicochemical properties, such as high surface area and tunable surface chemistry, make them ideal candidates for such applications [2]. Biomedical engineering has also acknowledged the promising function of silica nanoparticles in a variety of applications [3]. Biosynthesis of silica nanoparticles, such as wheat husk, has attracted significant interest as an environmentally safe and cost-effective method for developing nanomaterials with potential biomedical applications. Wheat husk husk-derived silica nanoparticles have desirable characteristics, including biocompatibility and a high ratio of surface area to volume, making them suitable for biomedical applications. These nanoparticles can be functionalized with specific molecules, such as antibodies and peptides, to target specific human cells or tissues [4]. This study, titled "Biosynthesis and Biomedical Applications of Silica Nanoparticles (Si-Nps) from Wheat Husk for Arsenic Removal," aims to highlight the potential of biosynthesized silica nanoparticles from wheat husk for biomedical applications, particularly in the context of arsenic removal. The study aims to contribute to the creation of efficient and environmentally friendly nanomaterials in the field of biomedical engineering by using wheat husk as a sustainable and renewable source for nanoparticle synthesis [5]. Research into wheat husk-derived silica nanoparticles for their biological uses is highly valuable in addressing the issues related to arsenic-contaminated soil and water. This research constitutes a key area of study, connecting the disciplines of environmental engineering and biomedical engineering.

## 2.2 MATERIAL AND METHOD

After carrying out the extraction of the Si-NPs from wheat using the sol-gel method, it should go under some tests using a High-powered microscope (HPM), Fourier transform infrared (FTIR), and UV-VIS Spectroscopy machines for the arsenic adsorbent analysis test.

Figure 2.1 illustrates the production steps of silica nanoparticles.

**Figure 2.1:** Production steps of Silica Nanoparticles

From the raw material obtained, the wheat ash is produced by conducting a combustion process of the wheat until it becomes ashes. From the obtained ashes, extraction of the silica nanoparticles using Sol-Gel method where the wheat ash will be dissolved with alkali solution to form sodium silicate and lowering pH to 7 by adding hydrochloric acid to form silica aqua gel followed by drying to form silica xerogel. The incinerated wheat is smashed thoroughly to make it into fine particles for it to dissolve easily into the further added solutions. Then the fined wheat ash is measured 5 grams for each small tray until it becomes 40 grams. The preparation sodium hydroxide (NaOH) solution is done by using 20-gram pellets with 500 ml of distilled water, and the solution is allowed to be stirred constantly using magnetic mixer. The preparation of the 3N Hydrochloric Acid (HCL) is completed in the ventilated enclosure called fume hood. The 20 gram of corn cob ash is then mixed with sodium hydroxide (NaOH) and let it for constant stirring for one hour with 100°C to produce sodium silicate solution. After stirring of the wheat ash with sodium hydroxide, the solution is cooled down to room temperature and is filtered through Whatman No. 41 ashless filter paper and the pH of the solution was reduced with 3N HCL prepared previously to 7.0 with constant stirring and incubated to promote gel formation. The silica xerogel was aged in a sealed vessel with an aluminum lid, then subjected to centrifugation at

400 rpm for 10 minutes. The recovered white silica was dried at 80°C for 12 hours and subsequently crushed into a fine powder.

## 2.3 RESULTS AND DISCUSSION

### 2.3.1 SYNTHESIZED SILICA SIZE EVALUATION USING FIELD EMISSION ELECTRON MICROSCOPY

The examination of the surface morphology of silica nanoparticles continued using Field Emission Scanning Electron Microscopy (FESEM). Analytical images of the observed morphologies were obtained using an advanced form of high-resolution imaging as shown in Figure 2.2. The experiment revealed various sizes and shapes of silica, attributed to different aging and temperature conditions leading to complete core reactions. Silica particles were obtained through multiple steps involving centrifugation and the finest filtration method using Whatman Filter paper no 5 (47mm).

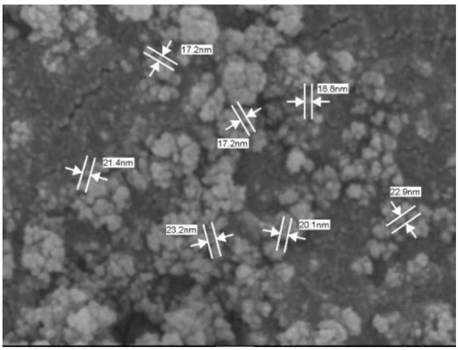


**Figure 2.2:** FSEM **i**mage of the synthesized silica particles

According to the FSEM analysis, it is evident that the silica nanoparticles derived from wheat husk ashes measure less than 100nm. This result is attributed to the aging process. Following 24 hours of allowing the solution to undergo reaction and aging, neutralization to pH 7 was achieved using diluted hydrochloric acid within a timeframe ranging from 60 seconds to 220 seconds. The remaining experimental conditions and reagents remained consistent with routine procedures. Dilution has been identified as a factor reducing coalescence, and neutralization maintained the rate of condensed silica. This process indicates that prolonged neutralization and aging may contribute to the production of smaller silica particles.

### 2.3.2 SYNTHESIZED SILICA BONDING EVALUATION USING FOURIER TRANSFORM INFRARED METHOD

The evaluation of synthesized silica chemical bonding is done using Fourier Transform Infrared (FTIR) to investigate their chemical boding and purity. The FTIR instrument was utilized to monitor the vibrational stretching and bending bands within the silica.

The FTIR spectra of the synthesized silica powders are depicted in Figure 2.3. As shown in the figure, the transmission peaks observed at 90 and 1500 $cm^{-1}$ correspond to the bond-rocking and symmetric bond of the Si-O elements. Additionally, the bands located at 1047.81 are associated with the stretching vibration of asymmetric Si-O-Si units. The presence of adsorbed water, free surface silanol groups, and siloxane linkages can be easily discerned from the IR spectra of silica within the range of 600–4000 $cm^{-1}$.

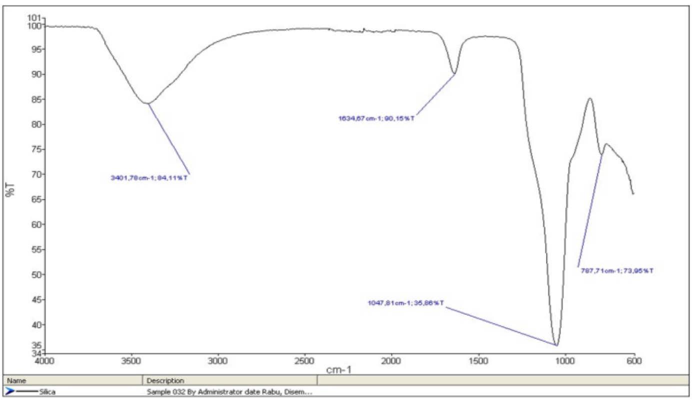


**Figure 2.3:** FTIR spectra of the synthesized silica particle

### 2.3.3 SPECTROPHOTOMETRIC EVALUATION ON THE INTERACTION BETWEEN ARSENIC AND ADSORPTION MATERIAL

The assessment of silica nanoparticle adsorption for arsenic removal was carried out utilizing a spectrophotometric method employing a UV/VIS machine. This particular analysis utilized the spectrophotometric approach with variamine blue as the chromogenic reagent for arsenic determination. Figure 2.4 illustrates the reaction of a 1 mg/ml arsenic concentration with varying concentrations of silica particles, ranging from 0 to 2.5 mg/ml. The findings indicate that a higher silica particle concentration (2.5 mg/ml) resulted in a substantial arsenic removal rate of 96%. This suggests that silica particles with elevated concentrations exhibit significant efficacy in removing arsenic heavy metal.

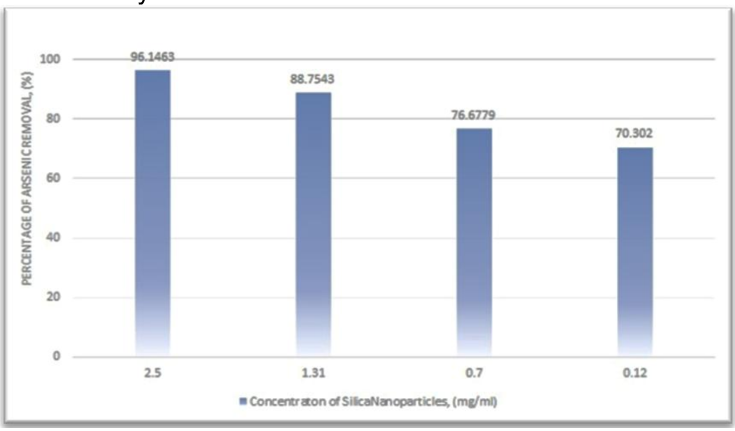


**Figure 2.4:** Arsenic concentration reaction towards various silica nanoparticle concentrations

The observed results underscore the significant potential of nanocomposites, emphasizing their remarkable properties. This is attributed to their unique surface area and active sites, making them highly suitable for adsorption analyses. The ability of silica nanoparticles to effectively remove arsenic heavy metal, as evidenced by the substantial removal percentage at higher concentrations, underscores the promising role of nanocomposites in enhancing adsorption processes.

## 2.4 CONCLUSION

This study successfully employed the sol-gel method to synthesize silica particles from wheat husk ashes, affirming the method's viability for biomedical applications. The morphological analysis conducted provided concrete evidence supporting the effectiveness of this synthesis approach. Importantly, the silica particles derived from wheat husk ashes using the sol-gel method exhibited a remarkable capacity for adsorbing arsenic heavy metal, highlighting their potential utility in addressing arsenic contamination in biomedical contexts. The synthesized silica particles hold promise for integration into biomedical formulations, where they could serve as a valuable component for mitigating arsenic toxicity. Particularly, in medical applications where water purity is crucial, the incorporation of silica nanoparticles may prove beneficial in reducing arsenic levels. This highlights a potential biomedical application of the synthesized silica particles for addressing health-related concerns associated with arsenic exposure. Silica nanoparticles have demonstrated effective adsorption capabilities for the removal of arsenic, as evidenced by spectrophotometric analysis assays. Notably, the synthesis and production of this nanomaterial are straightforward, adding to its appeal. What sets it apart is its ability to compete favourably with other commercially available adsorbents for arsenic removal, all while utilizing waste products in its production. This simplicity and sustainability make silica nanoparticles a promising candidate for arsenic remediation, highlighting their potential as a cost-effective and environmentally friendly solution.

## ACKNOWLEDGMENT

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