Novelty Studies on Amorphous Silica Nanoparticle Production From Rice Straw Ash

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Abstract. Turning waste product into the valuable resources is the best alternative way to overcome the waste management issue. Generally, rice is grown and planted twice a year where a lot of rice by-products have been produced after harvesting the matured paddy. Rice straw is one of turning waste products into the valuable resources and to manage the environmental issues. Generally, rice is grown and planted twice a year where a lot of rice by-products are produced. Rices straw is one of the rice by-products, generated roughly 0.7-1.4 kg per kilograms of harvested milled rice. With the nanotechnological approach, silica particles at nano-size can be produced using the incinerated rice straw. In addition to that, this research will report the synthesis, characterization and adsorption analysis towards the heavy metal removal.

1. Introduction

Rice is the staple food for the most population in the world [1-3]. Any scarcity or destruction of rice is primarily due to plant diseases, pest infection, and natural disaster will trigger the public and national concern, as in the case of Malaysian rice [4-7]. In Malaysia, based on earlier report in 2016 people consumed atleast 80 kg of rice (per peson), where mathematically 26% of the total caloric intake per day only by eating the rice-based food. The average expenditure for each family costing is about RM 44/month [8].

Malaysian government is willing to support the program focused on rice because it is a staple food of the vast majority of the population. Malaysia has vast land area for cultivating paddy plantation but still it is not adequate to supply the rice to all Malaysians and to overcome this issue the government imported the rice from Thailand, Vietnam, Pakistan and China [9]. Besides that, to ensure the sufficiency of food supply especially rice, the contributions from MADA, KADA, KETARA, IADA are necessary in order to help and realize the adequate level of rice production in the country [10].

Currently, there are several challenges in preserving the rice due to the above mentioned factors, even there are different researches have been carried out. Nowadays, everyone is struggling to have safe-food; however, metallic contamination of paddy land has become a serious issue because it affects...
millions of people who consume the rice. In Malaysia, rice is regarded as a trademark of our culture. Predominantly, Malaysian and people from other Asian countries consume the rice daily and many rice-based product such as bihun, mee, and laksa have been produced. However, the cultivation approach of rice in Malaysia is already exposing the rice with metallic contamination like Arsenic (As) [11]. It occurs naturally and taken-up by the paddy plants from the water and soil where arsenic contamination significantly affects the paddy development such as plant height, effective tiller number, straw weight, and reduction of rice grain [12].

Nanotechnology application play a vital role for any discipline work and research [13]. In modern agricultural sector, scientists and researchers apply nanotechnology for the agricultural production to boost the yield due to the rapid growth of human population in the world, which has incredible capabilities in these sectors. Fortunately, by using nanotechnology approach such as, silica nanoparticle production this study could able to minimize the problems of metallic contamination like Arsenic. Found to have huge capacity of improved resistance from plant diseases, improved quality of plant growth and increase high-yeld [14, 15].

2. Methodology

2.1 Silica extraction from Paddy Straw Ash

Raw paddy straw was supplied by rice mill in Perlis. Distilled water was used throughout the experiments. All chemicals were used as received without further purification. The process of nanosilica preparation was prepared with some modifications. Briefly, paddy straw was cleaned by de-ionized water and dried naturally for 3 days. Then paddy straw was burned and collected the ash. Approximately 20 g of ash paddy straw was mixed with 400 ml of 2.5 M of NaoH and stirred at 100°C for 4 h. Solution was filtered using Whatman filter paper, and titrated slowly using 2 M of sulphuric acid while it was stirred until reach pH 7. The stirring was continued until 18 h. Then stopped and waited until it forms two separated layers. The gel was separated by centrifugation (6,000 rpm, 5 min), washed three times with ethanol and two times with water and the washed gel was dried at 80 °C for 30 min. The outlined method with illustration is shown as figure 1.

2.2 Scanning surface morphological analysis

In this study, several morphological studies were carried out for the identification with the production of silica nanoparticles. Morphological characterizations were performed using high power microscope (HPM), field-emission scanning electron microscope (FESEM), scanning electron microscopy (SEM) and 3D nano profilometry. The samplings were prepared similarly for all scanning characterizations. At
first, approximately 1 mg of silica nanoparticles powder was dissolved in 50 μl of distilled water. Then a drop of silica was dropped on slice of silicon wafer before the measurement being started.

2.3 Adsorption analysis using UV-Vis spectrophotometer
Briefly, 1.2 gram of silica was weighed and diluted in 1.2 ml of distilled water. Then serial dilution was performed from the stock solution (1.0, 0.8, 0.6, 0.4, 0.2 mg/ml). Next, each silica concentration was distributed in Eppendorf tube with the concentration of 2 mg/ml of arsenic solution for UV-Vis measurement. Each sample was measured using nano-drop (The NanoDrop® ND-1000) at the range of 220-750 nm.

2.4 Antimicrobial study against pathogens infects paddy samples using nanomaterial
Firstly, infected plant leaves were taken from Biosphere Green House and kept preserved in chiller at 0 °C celcius. After that, the small portion of infected area were cultured using the nutrient agar media and sterilized. The infected leaves were incubated at 30°C for 2 days then subcultured on a new nutrient agar media for the reserved culture. Mc Farland turbidity standards were prepared for antimicrobial testing susceptibility process. 80 μL of broth culture of the test organism were transferred to nutrient agar plate. The broth culture was spread evenly and covered the agar surface. Sterile filter paper were used where 20 μl of Ampicillin (control), commercial silica (20 nm), produced silica and graphene and distilled water (negative control). The immersed filter were placed in the designated area on the inoculated petri dish. The plate was incubated for 24 hours at 35°C. The results was recorded where the zone of inhibition was measured in mm.

3. Results and Discussion

3.1 Morphological Studies on Silica Extraction
In this experiment, silica nanoparticles were prepared using the paddy straw. These by-products were produced annually after harvest was collected from the paddy field. Traditionally, most farmers will dispose the paddy straw by burning before new planting season comes, thus leads to the air-pollution [16]. These nanoparticles were prepared through the hydrolysis (sol-gel method). Based on images from figure 2, the average size of the particles measured was around 0.08-0.09 μm. The size of this nanoparticle produced was obtained by the application of nano-sized filter paper with a smaller pore size. Thus, this will lead to yield the nano-sized particles with a great potential in agricultural and medical applications. The nanomaterial has been considered only less than 100 nm sizing [17].

Figure 2. SEM morphological analysis for sizing measurement of silica nanoparticles.

Apart from that, the analysis is also revised and compared between rice straw ash and silica nanoparticles. Based on images received from HPM as shown in figure 3 (a-b), we can state that rice straw ash has more compact structure compared to silica nanoparticles. This structure was formed due to the process of burning had been affected by the changes of the surface structure. However, for silica nanoparticles, we can see a broad and spherical-structure form the images. To be detailed on images 3
(c-d) from FESEM measurement, we can observe that rice straw ash looks like surfaces in irregular forms with compressed particles and some parts its look as needle-like structured (figure 3c). However, for silica nanoparticles, we can observe that high porosity of structured silica nanoparticles is formed as compared to the raw material of rice straw ash. Apart from that, we can observe that spherical-like structure was formed after the reaction treatment between high alkaline and acid solutions (figure 3d). Next, for 3D nano profiler images, images captured give details on the height of materials and distribution of particles after dropped onto the wafer. Based on images 3(e) the raw materials of rice straw ash was captured and the maximum height was recorded is 143408.39 nm and next for silica nanoparticles the maximum height was recorded is 151541.438 nm. Based on this measurement we can observe the changes in height occurred before and after treatments to produce silica nanoparticles.

![Figure 3](image)

**Figure 3.** Morphological Analysis using HPM for (a) Rice straw ash; (b) Silica nanoparticles. FESEM at 100K magnification (c) Rice straw ash; (d) Silica nanoparticles. 3D view analysis for (e) Rice straw ash; (f) Silica nanoparticles.

### 3.2 Adsorption Analysis using UV-Vis Spectrophotometer

There are several studies for the removal of arsenic from aqueous solutions. One of the well-known methods is adsorption technique where most of the material used was inexpensive and easy to obtain [18]. In this experiment, silica nanoparticles from rice straw act as adsorbents (materials) for measuring the removal of arsenic in aqueous form. Based on this analysis, the highest concentration of silica nanoparticles will adsorb more arsenic. Its because the highest concentration of silica nanoparticles has the highest adsorption capacity for arsenic interaction as shown in figure 4. Apart from that, to enhance the adsorption of arsenic some authors suggested to modify the materials which consist of an iron element where this element will help to speed-up the reaction though the process wherein nature the adsorption is slow [19].
3.3 Antimicrobial Activity Analysis

For antimicrobial activity, disc diffusion method was used to test the anti-bacteria activity. All inhibition zone was recorded and figure 5 below showed the antibacterial testing from different types of sample. Ampicillin was chosen as a control because it acts as resistance to the most bacteria and has a cross-resistance to others pathogens [20]. Based on figure 4, the results show that silica has potentially positive effects as antimicrobial against pathogens and inhibit bacteria with a clear hollow zone. Commercial silica with 20 nm has the highest inhibition zone of 0.9 mm due to its size, which plays an important role when reacted with pathogens. The nanoparticle with a smaller size has a larger surface area to volume ratio in which more percentage of bacterial or pathogens will adsorb.

However, based on the previous studies by Umadevi et.al [21] stated that if the particle size is much smaller less than 10 nm, thus creates an electronic effect when the nanoparticle reacts with any bacteria or pathogens and as a result, it will develop the mechanism of the nanoparticles. For this reason, the reaction of pathogens is directly proportional to the size of particles. Thus it is proven that commercial
silica has shown the highest hollow zone compared to the silica with only 0.7 mm hollow zone because the particle size obtained was around 70 nm. In this experiment, distilled water and ampicillin act as negative and positive controls, respectively. As a result, for the negative control, there is no positive effect in the inhibition zone. For the positive control, it showed the highest size hollow zone due to the ampicillin acts as an anti-microbial agent [22]. Thus this analysis proved that, produced silica nano particles be able to act as antimicrobial agents.

4. Conclusions
From the research, silica nanoparticles shown to be an effective adsorbent for the removal of arsenic in aqueous forms. Apart from that, the sizing also plays important criteria as a good adsorbent where 80-90 nm particles size was produced. Besides that, silica nanoparticles also capable to act as antimicrobial agents for combating the pathogens.

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