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# Production of Silica from Biomass Ashes

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**Abstract**

Utilization of the ashes from biomass in the useful application will contribute to the sustainable use of biomass for power generation. For ashes that cannot be recycled, they must be transferred to other useful materials or compound, such as silica. So it is the source of the purpose of the project to produce silica from biomass ashes to utilize as building material or component in building product. Silica extraction process was carried out without controlled raw material from power generation plant. In this study, an attempt is made to introduce a simple process to produce precipitated silica from biomass ashes. The result was shown that the biomass ashes material contained with 21.37 wt% of Si, 14.29 wt% of C, 62.98 wt% of O, 0.14 wt% of Mg, 0.15 wt% of P, 0.72 wt% of K, 0.36 wt% of Ca, Silica was extracted to obtain 77.82 yield% and the average particle size of 4-20 μm.

**Keywords:** Biomass ash, silica, silica extraction

## Introduction

Almost Thai people are agriculturists. So there are many agricultural wastes such as rice husk, bagasse, straw, and garbage etc. All agricultural wastes are biomass. When biomass is burned, organic in biomass is released as heat and ash. This project used biomass ashes from biomass which is burned to generate electricity. Ashes cannot be recycled but can add value by produce silica into nanoparticles size. Production of silica can be applied to many industries. For example paint, color rubber, plastic, cement, and modified magnetic material [1]. In addition, it is a cost-effective resource and environmental protection.

A biomass was burned to generate electricity contained with silica, carbon, potassium, calcium, and magnesium etc. This biomass came from any kinds of plants such as lumber of Para wood or Rubberwood, Eucalyptus, Conifers, some softwood in Thailand, and bagasse. No controlling the burning conditions like combustion temperature and time, high impurity and fine particle size can be produced. The two factors of combustion temperature and time are defined silica in biomass ash remains crystalline or amorphous. [2] Silica is an oxide of silicon with the formula $SiO_2$, white crystal with 2.2 – 2.6 of specific gravity. [3] In the natural, most commonly found as 3 types; 1. Quartz 2. Tridymite, and 3. Cristobalite. About 95 % of silica dioxide produce is consumed in the construction industry. There are many methods to produce nanoparticles size of silica. For example 1. Sol-gel techniques is a well-established colloidal chemistry technology, which offers the possibility to produce various materials with novel, predefined properties in a simple process and at relatively low process cost. [4] 2. Flame spray pyrolysis process is a highly promising and versatile technique for the rapid and scalable synthesis of nanostructured materials with engineered functionalities. The technique was initially derived from the fundamentals of the well-established vapor-fed flame aerosols reactors that was widely practiced for the manufacturing of simple commodity powders such as fumed silica, and alumina etc.[5] 3. Hydrothermal method is A synthesis method for growing single crystals from an aqueous solution in an autoclave (a thick-walled steel vessel) at high temperature and pressure. [6-7], and 4.Precipitation method. In this study, precipitation method is used. This is a facile way which attracts considerable interest in industries because of low energy and temperature, inexpensive and cost-effective approach for large-scale production and good yield.[8] The reaction of this process is

$$SiO_2\,(s) + 2NaOH\,(aq) \rightarrow Na_2SiO_3\,(aq) + H_2O\,(l) \qquad (1)$$

$$Na_2SiO_3\,(aq) + H_2SO_4\,(aq) \rightarrow SiO_2\,(s) + Na_2SO_4\,(aq) + H_2O\,(l) \qquad (2)$$

From equation (1) and (2), this ash is mostly amorphous silica which is reactive with NaOH solution at atmospheric pressure to yield sodium silicate at pH less than 10, silica is precipitated after sodium silicate reacted with sulfuric acid. Silica with the hydroxy functional group in silicon was called silanol (Si-O-H), which are pervasive on the surface of silica and related silicates. Because of their greater polar group, silanol can be fully condensed to give a polymer (the condensation polymerization of silano) [9-10]

## Materials and methods

A biomass ash as the precursor was given from the power plant in Thailand, NaOH as precipitating reagent to synthesize $SiO_2$ fine particles and $H_2SO_4$ as adjusting the pH of the solution was purchased from Sigma-Aldrich.

### Preparation

1. NaOH with a concentration of 2, 4, 6, 8, and 10 w/v%
2. 10 w/v% of $H_2SO_4$
3. Drying 20 g of biomass ash until it was constant. A biomass ash was observed by physical properties such as color, and the morphology, size, and elemental analysis of the sample was determined by Scanning Electron Microscope; SEM and Energy Dispersive X-ray Spectrometer; EDS

Silica particles were synthesized by direct precipitation method using 20 g of the biomass ashes and different concentration of sodium hydroxide; 2, 4, 6, 8, and 10 w/v% respectively, as reactants, 90 °C under vigorous stirring at a different time; 30, 60, and 90 min respectively. After the reaction, the aqueous solution was filtered by using vacuum filter in order to separate the non-reactant. The red-brown aqueous solution was adjusted with 10 w/v% of $H_2SO_4$ to pH 7 which resulted in the formation of a white suspension. The white solid particles were filtrated by vacuum filter and washed many times with distilled water. The obtained product was dried on the electric oven at 110 °C for 3 h. After that the product sample was mortared to get a fine powder, to obtain the yield of silica and characterized by Scanning Electron Microscope; SEM and Energy Dispersive X-ray Spectrometer; EDS

## Results and discussion

For the analytical study of the prepared sample, the elemental analysis of biomass by Scanning Electron Microscope; SEM and Energy Dispersive X-ray Spectrometer; EDS was 14.29 wt% of carbon (C), 21.37 wt% of silica, and other elements such as K and Mg etc. see Table 1 and Figure 1. The morphology and size of biomass ash were determined by Scanning Electron Microscope; SEM with 10 kV, 1,000 times magnification, 250 μm. Biomass ash had a lot of porous, it is clear that Biomass ash particles exhibit nonspherical. This is the same as the previous studies of the rice husk ash. [11]

**Table 1 an elemental analysis of biomass ash**

| Element | Line Type | Apparent Concentration | k Ratio | wt % | wt % Sigma | Atomic % | Oxide % | Standard Label | Factory Standard |
|---|---|---|---|---|---|---|---|---|---|
| C | K series | 5.79 | 0.05786 | 14.29 | 0.20 | 20.08 | 52.34 | C Vit | Yes |
| O | | | | 62.98 | | 66.44 | | | |
| Mg | K series | 0.25 | 0.00163 | 0.14 | 0.01 | 0.10 | 0.23 | MgO | Yes |
| Si | K series | 47.78 | 0.37862 | 21.37 | 0.10 | 12.84 | 45.72 | SiO2 | Yes |
| P | K series | 0.39 | 0.00216 | 0.15 | 0.01 | 0.08 | 0.34 | GaP | Yes |
| K | K series | 1.67 | 0.01419 | 0.72 | 0.01 | 0.31 | 0.87 | KBr | Yes |
| Ca | K series | 0.83 | 0.00742 | 0.36 | 0.01 | 0.15 | 0.50 | Wollastonite | Yes |
| Total: | | | | 100.00 | | 100.00 | 100.00 | | |

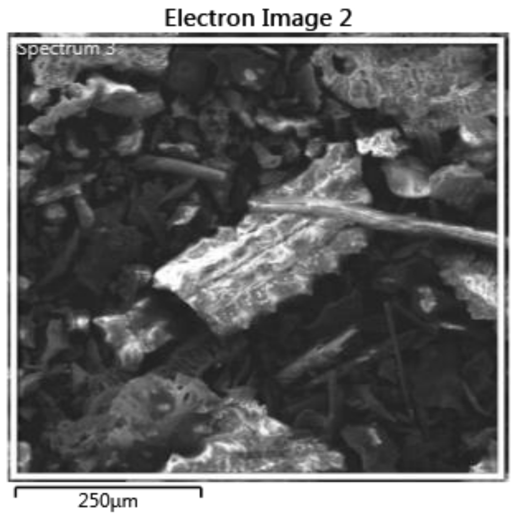


Fig. 1 The morphology and size of biomass ash

The result of this study was shown in Figure 2 that the condition was 8 w/v % of NaOH, 60 min, at 90 °C to get higher yield% of silica (77.82 %). Because of the stoichiometry of 8 w/v % of NaOH was suitable to $SiO_2$ to obtain high yield% of $Na_2SiO_3$ and titrated with 10 w/v% of $H_2SO_4$ to pH 7 under vigorous stirring. Sodium silicate has shown to be neutralized with diluted sulfuric acid to precipitate silica. [12] (Equation 1 and 2)

Figure 3, it was shown that the difference of physical properties between biomass (black color) and silica after leaching of $Na_2SiO_3$ by 10 w/v% of $H_2SO_4$ has led to the production of pure white silica (white color).

Figure 4 Scanning Electron Microscope; SEM with 10 kV, 1,000 times magnification and Energy Dispersive X-ray Spectrometer; EDS was used to prove the existence of fine particles of $SiO_2$. It can be observed that the shape of the silica particles was the polygon. The average size of fine particles synthesized is 4-20 µm.

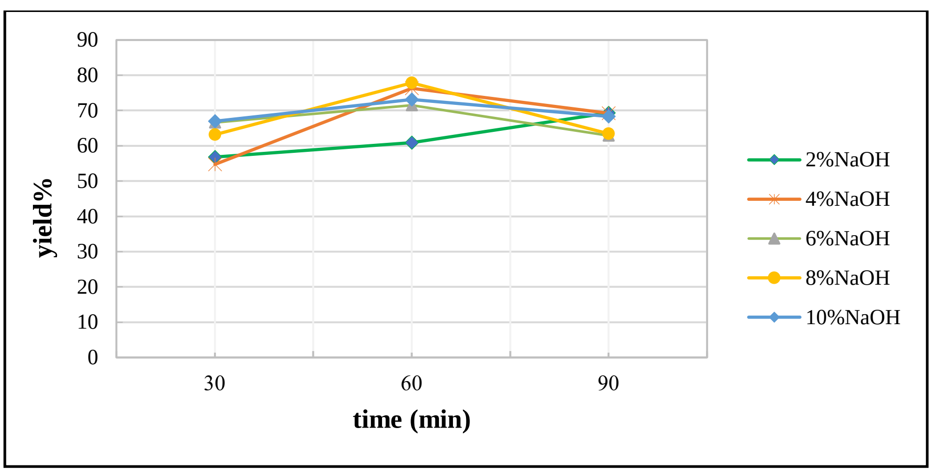


Fig. 2 The percentage of yield of $SiO_2$ as a function of time in the reaction

Fig. 3 Comparison of biomass ash and silica particles

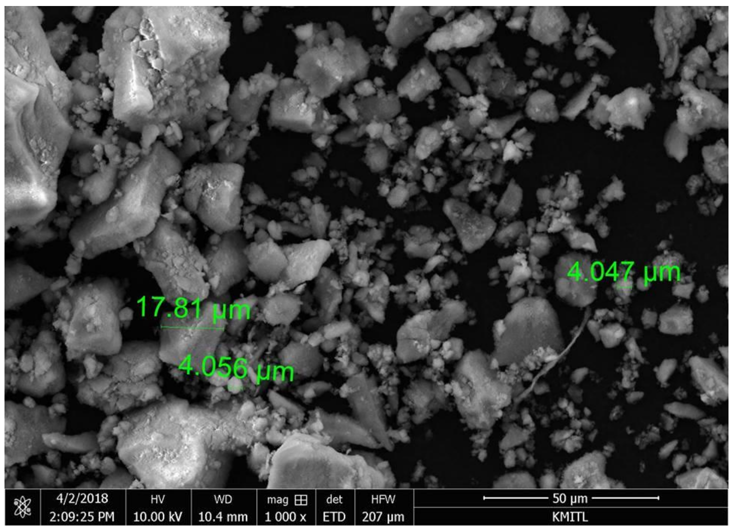


Fig. 4 The morphology and size of $SiO_2$

## Conclusion

In this project, the silica particles were synthesized by precipitation method using biomass ash as the reactant and NaOH as a precipitating agent in aqueous solution. The precipitation method is convenient to expand production in the industry, low power consumption, and temperature, and good yield, the optimized condition was 8 % w/v of NaOH, 60 min, at 90 ₒC to get 77.83 % yield. The size range of silica product was approximately 4-20 μm.

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