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Extraction of Silica from Burnt Paddy Husk

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Abstract : Burning the fuel, rice hull to generate energy results in the waste product called rice hull ash (RHA). RHA is an abundant agricultural by-product. It is rich in silica (about 60%) and can be made into economically viable raw material which can be used for production of silica gels and powders. The present work deals with the production of silica particles. Acid washing prior to extraction resulted in silica with a lower concentration of minerals. Synthesis was done by precipitation using different acids namely, sulphuric acid and nitric acid which yielded nanosilica. The effect of different acids on the size and degree of agglomeration of the silica particles were studied and the formed silica is sorted out for various uses. This process is inexpensive, sustainable, environmental friendly and also suitable for large scale production.
Key words: rice hull, silica gels, xerogels, agglomeration

1. Introduction

During the last two centuries, human activities such as the production and consumption of fossil fuels, as well as agricultural and industrial activities have caused an increase in the atmospheric concentration of greenhouse gases[1]. Fossil fuel shortage and environmental problems have created the urgency for the exploitation of clean renewable energy[2]. So, many countries have put forward plans to reduce carbon dioxide emissions and energy consumption.

Biomass is one of the most promising energy-carrying agent and can play an important role in environmentally friendly energy utilization. Rice husk (RH) is an important agricultural residue[3]. Most of RH will burn as fuel to generate energy resulting in the waste product, rice husk ash (RHA). If these RHA are not utilized, it will result in tremendous waste generation, energy loss and environmental pollution. Therefore, it is very important to find ways to utilize RHA comprehensively[4].

RHA usually contains more than 60% silica (SiO_2), 10–40% carbon with minor mineral composition. Rice husk ash has a relatively high content of inorganic compounds, representing approximately 20% of the dry weight of the husk. Silica represents 94% of the total while the remaining 6% are K_2O, CaO, MgO, Al_2O_3, and P_2O_5 in decreasing concentrations. Silica (SiO_2) is a basic raw material that is widely used in electronics, ceramic, and polymer material industries. Because of its particles diameter, ultrafine silica powders have many technological applications, such as thixotropic agents, thermal insulators, composite fillers, etc[5].

Silica also has been used as a major precursor for a variety of inorganic and organometallic materials which have applications in synthetic chemistry as catalysts, and in thin films or coatings for electronic and optical materials.

Silica gel from rice husk ash can be roughly prepared by two ways, that is to say the thermal treatment with temperatures ranging from 500-1400^{o}C. This method requires high temperature. The second way of preparation is leaching by acid or basic solutions and then neutralization by acid to produce silica gel. The latter consumes low energy, and is cost-effective compared to the current melting method. Besides this advantage, the process may decrease CO_2 emission due to the current manufacture of sodium silicate from the reaction of Na_2CO_3 and SiO_2.

The objective of this study was to investigate the effect of, washing RHA with different acids (HCl, HNO_3 and H_2SO_4) prior to alkali extraction, the degree of agglomeration and yield of silica.

2. Materials and Methods

2.1 Materials

RHA was collected from brick factory located at Arakkonam, Tamil Nadu, India, which is a residue from pyrolysis of rice husk. This pollution-carrying residue (RHA) was utilized as material in our work. All chemicals are analytical grade and used without further purification. The acid and other chemicals were obtained from Alphaa Enterprise, Erode. Distilled water is applied for all synthesis and treatment processes.

2.2 Acid Pre-Treatment of Material

The aim of acid pre-treatment is to improve the purity of silica product. It proves to be an effective way in substantially removing most of the metallic impurities and producing ash silica completely white in colour. It was conducted in the following manner. Ten grams of RHA samples were dispersed in 60 ml of distilled water, and the pH was adjusted to 1, 3, 5 or 7 using 6 N HCl, HNO_3, H_2SO_4.These dispersions were stirred for 2 h, filtered through Whatman No. 41 ashless filter paper and then the RHA residues were washed with 100 ml of water. The residues were used for silica extraction. The filtrate and washings at each pH were collected and dried in an evaporating dish[6].

2.3 Silica Extraction

60 ml portions of 1N NaOH were added to the washed and unwashed RHA samples separately and boiled in a covered 250 ml Erlenmeyer flasks for 1 h with constant stirring. This step is to dissolve the silica and produce a sodium silicate solution. The solutions were filtered through Whatman No. 41 ash less filter paper, and the carbon residues were washed with 100 ml of boiling water. The filtrates and washings were allowed to cool to room temperature and were titrated against 1N HCl with constant stirring to pH 7. Silica gels started to precipitate when the pH decreased to <10. The silica gels formed were aged for 18 h. Deionised water (100 ml) was added to gels and then the gels were broken to make slurry. Slurries were then centrifuged for 15 min at 2500 rpm, the clear supernatants were discarded and the washing step was repeated. The gels were transferred into a beaker and dried at 80^{o}C for 12 h to produce Xerogels[6].

2.4 Moisture Content Of Silica Gels

Moisture content of the silica gels was determined using an air oven method (AOAC, 1990). About 1 g of each sample was heated for 1 h in an aluminium moisture pans at 130^{o}C. The samples were cooled in desiccators and weighed. The weight loss (%) was recorded as the moisture content of samples[6].

2.5 Chemical Analysis of Silica Powders

The silica samples obtained using different acids and degree of agglomeration of silica particles were analysed using Scanning Electron Microscopy (SEM)[7]

3. Results And Discussion

3.1 Effect of Different Pre-Acid Wash Treatment on Silica Yield

The SEM image of extracted silica particles using Hydrochloric Acid, Nitric Acid and Sulphuric Acid are shown in Fig. 1, Fig.2 and Fig. 3 respectively. In the present work, it is observed that, the degree of agglomeration of silica particles is high when hydrochloric acid is used in washing process.

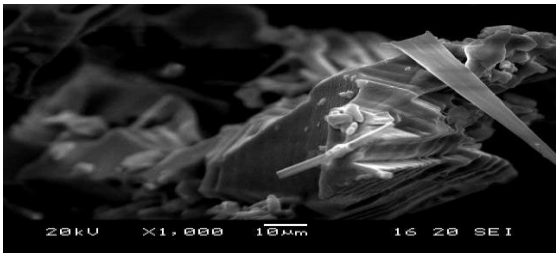

Fig 1 SEM image shows silica particles obtained by using HCl in acid washing

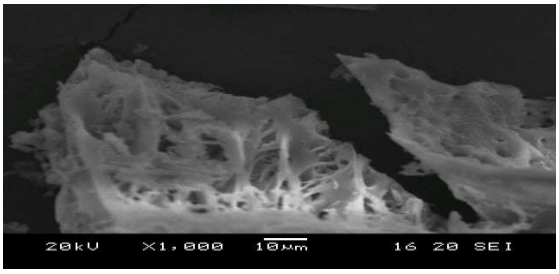

Fig 2 SEM image shows silica particles obtained by using HNO_3 in acid washing

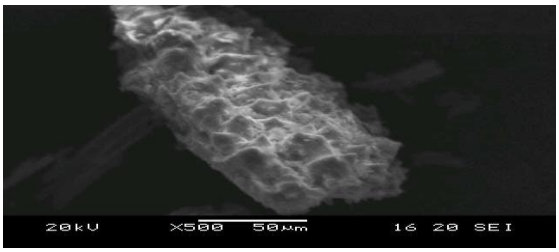

Fig 3 SEM image shows silica particles obtained by using H_2SO_4 in acid washing

In the pre-treatment process we used three different acids (HCl, HNO_3 and H_2SO_4) for washing RHA. Silica is extracted from this pre-treated RHA using various concentrations of NaOH. It is found that the yield of silica is strongly dependent on the type of acid used for washing and concentration of NaOH. The results are shown in the Table 1 and Fig. 4. This study revealed that, the yield of Silica is more (85%) when Hydrochloric acid was used for washing at 1 N concentration of NaOH.

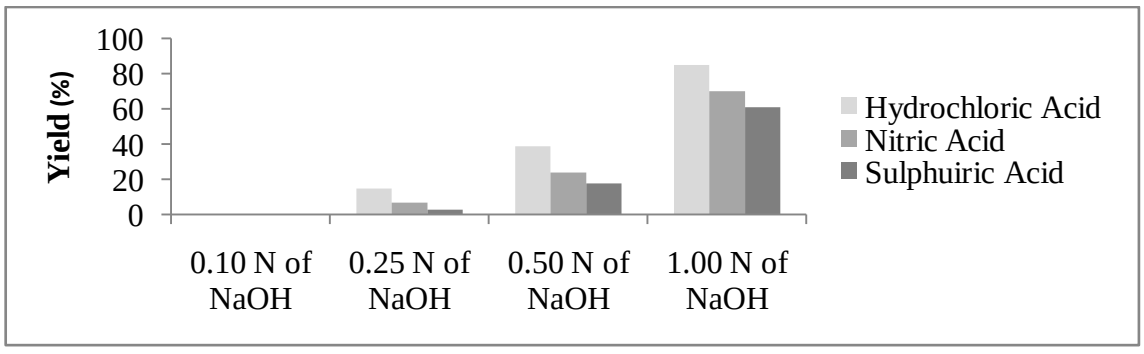

Fig.4. Effect of Concentration of Sodium Hydroxide used for silica extraction on the yield of silica using HCl, HNO_3 and H_2SO_4

3.2 Effect of Pre-Acid Wash Treatment on Moisture Content

The effect of washing on yield of silica is studied at 1 N concentration of NaOH by using three acids in pre – treatment process and the results are shown in the Table 2 and are shown in Fig. 5, Fig. 6 and Fig. 7. We compared the moisture content of the extracted silica obtained from acid washed with unwashed RHA.

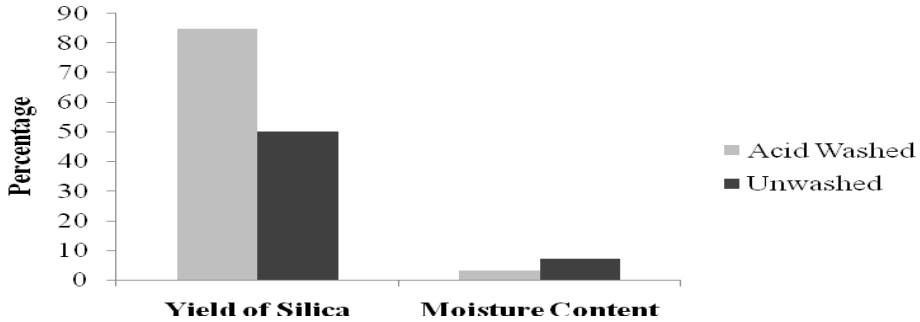

Fig 5. Comparison between HCl washed and unwashed silica particles for the yield and moisture content

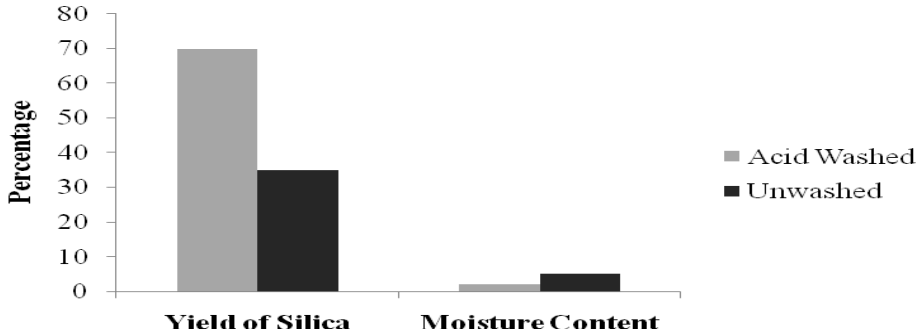

Fig 6. Comparison between HNO_3 washed and unwashed silica particles for the yield and moisture content

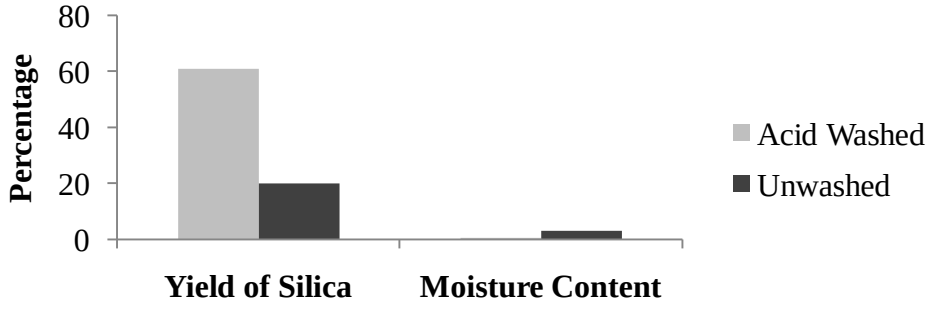

Fig 7: Comparison between H_2SO_4 washed and unwashed silica particles for the yield and moisture content

From the results, we can clear that the final moisture content of extracted silica gels depends on the type of acid used in initial acid washing process.

4. Conclusion

It was concluded from the study that, it was viable to extract the silica from Rice Husk Ash by Alkali extraction. Further, the results showed that, the percentage yield of extracted Silica is high when we used acid washed in spite of unwashed RHA. And also it is found that, the moisture content in the silica is low when acid washed RHA is used in place of unwashed RHA.

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