

Preparation of Silica Powder from Rice Husk

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ABSTRACT: Rice husk is an agricultural residue abundantly available in India. A huge amount of rice husk is discharged in India, and the rice husk is usually burned in the field, or in some cases it is used as a fuel for power plant. In both cases, the smoke generated with the burning process often causes serious domestic and also international environmental problems. It is very important to solve the problems, smoke and waste, in relation to the treatment of rice husk. Rice husk is one of the most silica rich raw materials containing about 90-98% silica. Rice husk large ash content and sodium silicate content in the ash it becomes economical to extract silica from the rice husk ash, which has wide market and also takes care of ash disposal. Rice husk is a popular boiler fuel and the ash generated usually creates disposal problems. The chemical process discussed not only provides a solution for waste disposal but also recovers a valuable silica product, together with certain useful associate recoveries. The sample characterized by FTIR & X-ray diffraction (XRD).

Keywords: Rice Husk, Rice Husk Ash, Rice Husk Silica, Sodium Silicate.

I. INTRODUCTION

Rice husk is a by-product of the rice milling industry. It is a unique crop residue with uniform size and high content of ash (14–25%). The silica content of the rice husk ash (RHA) can be as high as 90–98% [1]. This husk can be used as a fertilizer in agriculture or as an additive for cement and concrete fabrication. Due to its high silicon content, rice husk has become a source for preparation of elementary silicon and a number of silicon compounds especially silica silicon carbide and silicon nitride [2.]

India is a major producer of rice and finding ways to put the husk to use is imminent. The high silica content in the rice husk ash has attracted interest in discovering ways to use it commercially. Although silica occurs as a component of cells or cell walls in virtually all arial parts of the rice plant, it is most abundant in the husk. Owing to their small diameter, many technological applications, such as thermal insulators, composite fillers, etc., use ultrafine silica powders [3]. Hunt et al. [8] investigated the possibility of producing high purity silicon from rice husk by purifying the rice husk silica according to the method of Amick et al, followed by pelletizing and reduction in a modified electric arc furnace. The pelletizing was carried using carbon black as a reductant and sucrose as a binder. The authors concluded that purified RHA could be a potential silica source for solar grade silicon production.

Bose et al. [9] subjected powdered silicon obtained by magnesium reduction of rice husk ash at a temperature of 600-650 °C to melting and directional solidification and found that boron was the active impurity in the polycrystalline silicon ingot obtained. They determined the minority carrier life time of their polycrystalline silicon material to be of the order of 1-5µs and concluded that to be promising for photovoltaic applications. A minimum carrier lifetime requirement for efficient solar cells fabricated from multicrystalline silicon wafers is however estimated as 25 µs [11].

The magnesium reduction of rice husk ash has also been investigated by Banerjee et al. [10] and by Ikram and Akther [12]. Banerjee et al reduced acid leached rice husk ash by intimately mixing the ash with magnesium powder and firing the powdered mixture in a sealed graphite crucible in a muffle furnace. The reaction product was successively leached in mineral acids (HCl, H₂SO₄, and HF) in a Teflon beaker. A spectrochemical analysis of the final silicon product showed a high boron content of 20-200ppm as well as high magnesium (50-1000ppm) and aluminum (10-200 ppm). They attributed the contamination of the silicon to the use of laboratory grade magnesium and also from glassware. In comparison with the silica produced by Singh and Dhindaw, Banerjee et al. reported the silica had attained some degree of crystallinity when produced from roasting of husk at temperatures between 500-600 oC. In this study, the presence of crystalline silica in RHA sintered at temperature range 600-750°C were examined by X-ray Diffraction (XRD). The microstructure of this crystalline silica is also observed. [4]

Table 1: Chemical composition of RHA before and after burning out at 700°C for 6 h

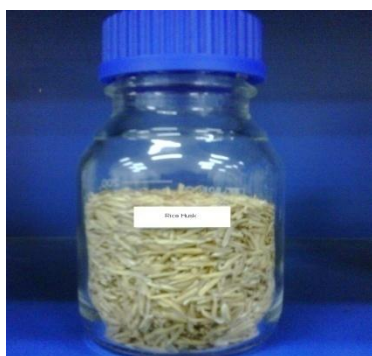
Components expressed as	RHA has received	RHA after burning out
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oxides		
SiO ₂	72.1	94.95
Al ₂ O ₃	0.30	0.39
Fe ₂ O ₃	0.15	0.26
CaO	0.43	0.54
Na ₂ O	0.50	0.25
K ₂ O	0.72	0.94
MnO	0.15	0.16
TiO ₂	0.05	0.02
MgO	0.70	0.90
P ₂ O ₅	0.06	0.74
Loss on fire	24.3	0.85

II. EXPERIMENTAL PROCEDURE

The first step for producing silica powder from rice husk consists of a thermal treatment at several temperatures. The aim of this step is to increase the relative amount of silicon oxide by reduction of carbonaceous materials Present in the samples, as well as to burn out other undesirable components detected by chemical analysis. The ash samples were submitted to heat treatment in ceramic crucibles. Heating cycles were carried out in air in an electric furnace with a heating rate of 5°C/ min. Each sample was held at a maximum temperature 700°C for 6 h. The samples were cooled down inside the furnace.

The procedure was repeated for the temperature ranges from 600-700°C. According to Krishnarao et al.(1992), Crystallization occurred at 800°C during firing (burning) of samples of rice husk, hence burning at 750°C or above can result into environmental pollution[5,6].



(a)



(b)



(c)

Figure: Photographs of (a) Rice Husk (b) Rice Husk Ash (c) Rice Husk Silica Powder

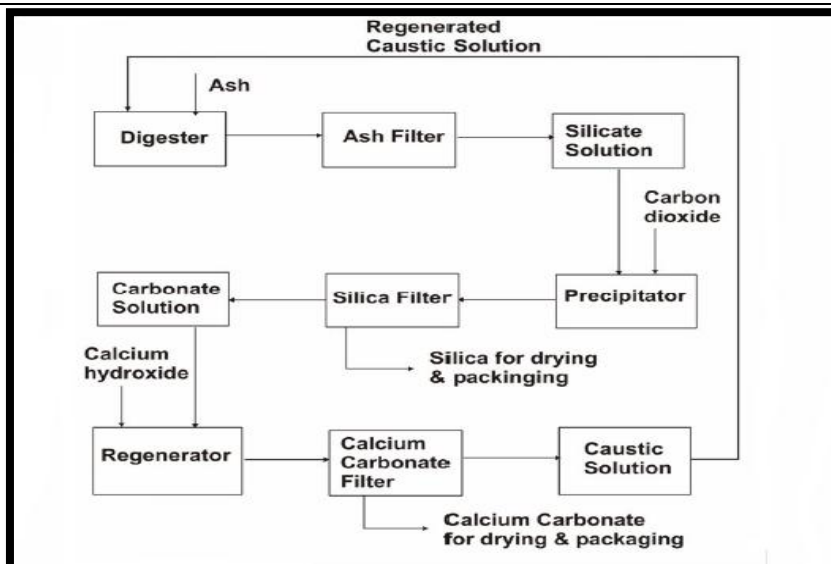


Figure: Experimental procedure diagram for the production silica

Silica was extracted from RHA adapting the method of Kamath and Proctor (1998). Sixty ml portions of 1N NaOH were added to the washed and unwashed RHA samples and boiled in covered 250 ml Erlenmeyer asks for 1 h with constant stirring to dissolve the silica and produce a sodium silicate solution. The solutions were filtered through Whatman No. 41 ashless 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 with 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. Chemical analyses of silica gels the silicon content of the samples was estimated using energy dispersive X-ray (EDX) spectroscopy (Kevex Instruments, Valencia, CA). [7]

III. RESULTS

RHA obtained from the burning of the husk yielded white silica powder. The silica powder obtained is almost similar to that of the commercial silica in terms of the functional groups, the amorphous nature and also the physical structure. The RHA sample after burning out at 700°C for 6 h presented the highest amount of silica (Table 1) compared to the other samples. This sample was chosen to be submitted to grinding. The relative contents of other elements increased in general with increase in temperature and time. Small divergences of this rule are probably caused by inherent the crystal structure of silica may determine its reactivity and degree of health danger. Whilst crystalline silica is less reactive and deemed carcinogenic, the amorphous silica is rather reactive and with no harmful effect. The XRD pattern of the as-received RHA is shown in Figure. The major reflections or peaks of crystalline quartz from ICSD powder diffraction files (PDF) occur at Bragg 2 θ angles of 36.541°. It can be seen that no defined peaks corresponding to these Bragg 2 θ angles are found in Figure. A rather broad peak spanning 2 θ which is characteristic of amorphous structures is observed.

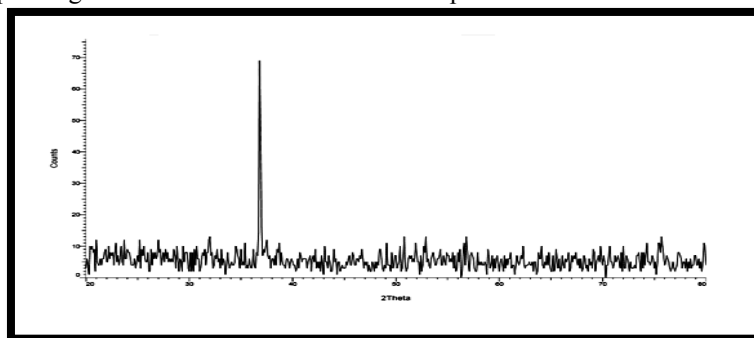


Figure: X-ray diffraction pattern of silica produced from RHA.

The FTIR spectrum in transmittance mode in Figure shows peaks at 3,383, 1,581, 1,063, 751, 612 & 546 cm⁻¹. The major chemical groups present in silica are identified by the FTIR spectra shown in Fig. The

broad band between 1581 and 3383 cm^{-1} was due to OH groups and adsorbed water. The predominant absorbance peak at 1303 cm^{-1} was due to bonds ($\text{Si}\pm\text{O}\pm\text{Si}$). The peaks between 1191 and 612 cm^{-1} are attributed to vibration modes of the gel.

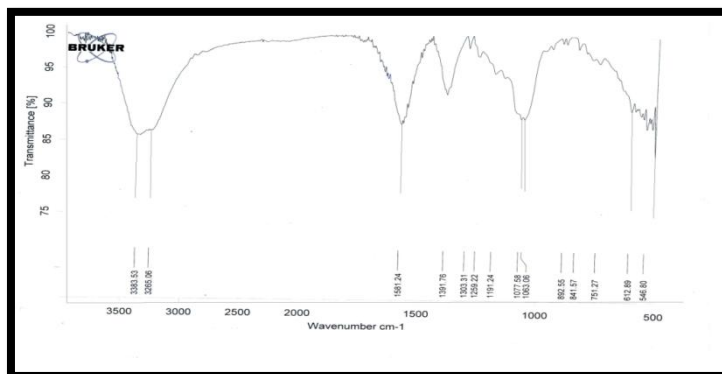


Figure: Fourier transform infrared spectra of silica produced from RHA

IV. CONCLUSION

Rice husk ash, which is an agricultural waste, can be converted into valuable product used for several applications in industry. Therefore the determination of exact quantity of silica powder is important for analyst to study its application. The percentage of silica content varies from 90-98% with the change of region. The silica obtained is very largely amorphous. The XRD shows only traces of quartz (crystalline form of silica). The silica has a small particle size making it suitable for use in rubber and ink industries.

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