Silica from Ash

A Valuable Product from Waste Material

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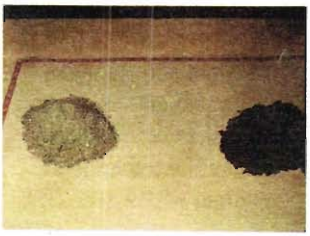
A simple chemical process is described for extracting amorphous silica from rice husk.

Introduction

Silica (SiO_2) is one of the valuable inorganic multipurpose chemical compounds. It can exist in gel, crystalline and amorphous forms. It is the most abundant material on the earth's crust. However, manufacture of pure silica is energy intensive. A variety of industrial processes, involving conventional raw materials require high furnace temperatures (more than 700°C). In this article, a simple chemical process is described which uses a non-conventional raw material *rice husk ash* for extraction of silica.

Rice husk ash is one of the most silica rich raw materials containing about 90-98% silica (after complete combustion) among the family of other agro wastes. 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.

Figure 1 Difference in color of the ash obtained from complete combustion and incomplete combustion.



Selection of Ash

The selection of ash is important as the quality of ash determines the total amount as well as quality of silica recoverable Ash which has undergone maximum extent of combustion is highly desirable as it contains higher percentage of silica. It appears white-grey in colour when compared to the black coloured ash obtained from incomplete combustion (*Figure 1*). The carbon present in such ash hinders the main silica digestion reaction and may change the product characteristics (colour, etc.). This method of quality assessment is more suitable to workers at the processing site as it does not involve lab-scale analysis.

Silica is digested from ash using caustic soda as sodium silicate. Reaction of sodium-silicate with sulphuric acid precipitates silica. The purification and drying produce silica in white amorphous powder form.

Process

The initial step is extraction of silica from ash as sodium silicate using caustic soda. This reaction is carried out at a temperature in the range 180°-200°C and pressure ranging from 6-8 atmosphere.
The reaction is:

$$\underset{\text{(ash)}}{SiO_2} + \underset{\text{(caustic soda)}}{2NaOH} \xrightarrow[\text{6-8 atm.}]{\text{180-200°C}} \underset{\text{(sodium silicate)}}{Na_2SiO_3} + \underset{\text{(water)}}{H_2O}$$

But high reaction temperature and pressure can be avoided if ash obtained by burning rice husk at 650°C is used. This ash is mostly amorphous silica which is reactive around 100°C with NaOH solution to yield sodium silicate.

A viscous, transparent, colourless sodium-silicate solution (~15%w/w) is obtained after filtration of the reacted slurry (consisting of residue digested ash, sodium-silicate, water and free sodium hydroxide).

In the second step of the process, silica is precipitated from sodium-silicate using sulphuric acid. This step requires controlled conditions of addition rate of sulphuric acid and temperature of reacting mass in a neutralizer. The temperature is in the range of 90-100°C and pressure is the normal atmospheric pressure.

The reaction is:

$$\underset{\text{(sodium silicate)}}{Na_2SiO_3} + \underset{\text{(sulphuric acid)}}{H_2SO_4} \xrightarrow{\text{90-100°C, 1 atm}} \underset{\text{(silica)}}{SiO_2} + \underset{\text{(sodium sulphate)}}{Na_2SO_4} + \underset{\text{(water)}}{H_2O}$$

Sodium sulphate from the effluent water and good quality bricks from ash residue are other recoveries.

The addition of sulphuric acid is done very slowly (otherwise the

Figure 2 Silica obtained after drying.

Box 1.
General Material Balance

Husk: 100kg
Ash content: 19.14kg
Total silica in ash:18.18kg
Extractable silica:11.82kg (65%conversion)
Residue ash:7.32kg
Residue quality: good for bricks

Results:
product: silica
purity: >98.0%, w/w
surface area: >150.0 m^2/g
byproduct: sodium sulphate
purity: >96.0%, w/w
Disposal problem: also solved.

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chemistry of reacting mass may change along with physical properties/form) until acidic conditions are reached. The acidic conditions indicate approximately complete precipitation of silica from sodium-silicate. A white precipitate of silica in solution of sodium sulphate is obtained.

The silica (wet impure silica) obtained above is filtered. Purification of this silica for removal of sulphate impurities constitutes the third step of the process. For this successive demineralized water washings are given in the filter process itself. The conductivity of the effluent follows a decreasing trend owing to removal of sodium sulphate. Thus, conductivity can be used as the criteria to decide the number of washings for obtaining silica of desired purity. Silica after removal of sulphates (wet silica) is generally spray dried to obtain the amorphous powder form in the final step of the process (*Figure 2*).

Associated Recoveries

The other associate recovery is sodium sulphate. Effluent wash water obtained after washing precipitated silica (wet impure silica) contains sodium sulphate. By evaporation of water in multiple effect evaporators, followed by crystallisation, filtration and drying, crystals of sodium sulphate are obtained. The residue ash in sodium silicate production can be utilized for making good quality bricks. Retained sodium silicate in residue ash acts as a binder and with incorporation of suitable ingredients high quality bricks can be manufactured.

Concluding Remarks

A summary of the process described here is presented in *Box 1*. The amorphous silica obtained using this method has many applications, e.g. as fillers in rubber products and paper, anti-sticking agent. It is an important catalyst in chemical industry and also serves as the raw material for the production of silicone.