



Utilization Of Rice Husk Ash For The Extraction Of High-Purity Silica

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Abstract

Rice husk ash (RHA), an abundant by product of rice milling, is an excellent source of silica, comprising 90-98% of its composition after complete combustion. This study explores a novel process to extract high-purity silica from RHA using an alkaline extraction method. The process also yields sodium sulfate as a by-product and resolves environmental challenges associated with RHA disposal. Experimental investigations were conducted to analyze the effects of extraction temperature, time, and sodium hydroxide (NaOH) concentration on silica yield. Statistical analysis using ANOVA determined that NaOH concentration and temperature significantly influenced silica yield, while extraction time had a minimal effect. The extracted silica exhibited desirable properties, making it suitable for diverse industrial applications.

Key words:

- Silica
- Rice Husk Ash (RHA)
- Extraction
- Sodium Hydroxide (NaOH)
- Sustainability

1. Introduction

Silica (SiO_2) is a versatile inorganic compound that exists in gel, crystalline, and amorphous forms. Traditionally, silica is produced by reacting sand with soda ash at temperatures exceeding 1500°C . However, this process is energy-intensive and costly. Alternatively, rice husk ash (RHA), a silica-rich byproduct of rice milling, offers an efficient and sustainable source for silica extraction. Approximately 25 million tons of rice husk are generated annually in major rice-producing states like Andhra Pradesh, Tamil Nadu, Karnataka, and Kerala, with a significant portion incinerated, causing disposal and pollution challenges.

This study introduces a process that utilizes RHA for silica extraction via alkaline digestion with NaOH , followed by precipitation with sulfuric acid (H_2SO_4). The process efficiently recovers silica and sodium sulfate while providing solutions for RHA waste management.

2. Materials and Methods

2.1 Materials

Rice husk was collected from a local rice mill .. Sulfuric acid (98%) and sodium hydroxide flakes were used as reagents, while distilled water served as the solvent.

2.2 Experimental Procedure

RHA was prepared by burning rice husk in a muffle furnace at 700°C for 2 hours. The ash content, moisture content, and particle size distribution were analyzed. The alkaline extraction process involved digesting RHA with NaOH to form sodium silicate, which was subsequently treated with H_2SO_4 to precipitate silica.

Key steps included:

- Burning rice husk to obtain white ash.
- Preparing 12% NaOH solution.
- Digesting RHA with NaOH in a 1:7 ratio.
- Filtering the sodium silicate solution to remove undigested residue.
- Precipitating silica with H_2SO_4 by reducing the pH below 10.

- Drying and characterizing the extracted silica.

2.3 Characterization

The extracted silica was characterized for specific surface area and moisture content. Statistical analysis using ANOVA assessed the impact of operating conditions (temperature, time, and NaOH concentration) on silica yield.

3. Results and Discussion

3.1 Thermal and Chemical Treatment

RHA combustion at 800-850°C yielded amorphous white ash, highly reactive for silica extraction. Acid washing significantly reduced impurities compared to untreated samples, as confirmed by ICP spectrometry.

3.2 Alkaline Digestion and Precipitation

Extraction parameters such as NaOH concentration and temperature greatly influenced silica yield, while extraction time showed minimal impact after optimal conditions were achieved. The combined effect of NaOH concentration and extraction time was statistically significant, enhancing silica yield.

3.3 Characterization of Silica

The extracted silica had a specific surface area of 93.6 m²/g and 3.2% moisture content, classifying it as xerogel. Purity exceeded 94.5 wt%, making it suitable for applications in rubber reinforcement, adhesives, cosmetics, and food products.

4. Applications

The precipitated silica market in India, estimated at 16,000 tons annually, caters to industries such as:

- Rubber (e.g., tires, shoe soles).
- Adhesives and sealants.
- Toothpaste and food anti-caking agents.
- Thermal insulation and dehumidifying agents.

Additionally, the by-product sodium sulfate finds applications in detergents, textiles, and chemical industries.

5. Conclusion

This study demonstrates the feasibility of extracting high-purity silica from RHA through a cost-effective and environmentally sustainable process. The process not only mitigates RHA disposal issues but also produces commercially valuable silica and sodium sulfate. Future work will focus on scaling up the process and exploring additional applications for the by-products.

References

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