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Valorisation of Rice Husk by Chemical and Thermal Treatments

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Abstract. In the industrial production of rice, large quantities of rice husk are generated constituting a residue with costs for the companies, which must be appropriately managed. The high grade of silica in the rice husk opens a possibility for its valorisation, through the production of amorphous silica with high porosity and potential application as ligand in construction materials, as catalyst support, as metals adsorbent, among others.

In this research work a process was developed for the production of silica with amorphous properties from rice husk waste, and the products formed were characterised. The process involved three main operations: water washing for removal of some impurities, acid leaching with HCl or H_2SO_4 solutions for dissolution of contaminating metals and incineration for organics decomposition.

The washing operation let a partial purification of the husk, allowing removal of 46-60% of contaminating metals such as K, Fe Mn and Zn. The leaching with 0.4M HCl and 0.2M H_2SO_4 allowed obtaining high metals removal efficiency, namely >99% for potassium, 85-90% for iron, >96% for manganese and >80% for zinc. The final composition of the leached husk was 0.003-0.006% K, 0.016-0.025% Fe, <0.001% Mn and <0.0007% Zn.

The incineration of the rice husk after previous purification was performed at 540°C, by using samples obtained in the several chemical treatment conditions, and using different heating and cooling rates. As a result, a white colored final husk ash was produced, rich in quasi-amorphous silica (confirmed by X-ray diffraction). The analysis by scanning electron microscopy revealed that the organics removal allowed the formation of voids in the rice husk material, which became very porous and presented an alveolar morphology.

Introduction

Rice husk (RH) is an abundantly available agricultural waste material in all rice producing countries. Dry rice husk contains 13-29% inorganic matter depending on the species, climate and geographic location [1, 2]. The inorganic matter is composed of silica (87-97 wt%) with small amounts of alkali and other trace elements. SiO_2 was localised in the outer and inner epidermis of the husk [3, 4]. Rice husk has many industrial applications. Sometimes, it is used for parboiling paddy in the rice mills, but its conversion to value-added products by thermal or chemical treatment makes it an important secondary resource material [5, 6].

Heating between 500°C - 800°C, RH gives ashes with higher than 90 wt% of silica with some carbon and other nonmetallic impurities. Ash properties depend on various pretreatments and calcination conditions [7]. Silica of high purity, chemical reactivity and white color can be produced from rice husk by controlling the heating conditions, getting the rice husk ash (RHA) with wide industrial applications. If the husk is not adequately treated, namely if it is partially burnt due to uncontrolled thermal conditions, its valorisation can be compromised. Under these circumstances, the RH in turn contributes to more environmental pollution.

The formation of black particles (carbon fixed) in rice husk silica ash obtained by calcination of untreated rice husks, is higher than that obtained in acid treated rice husks. The tendency to form black particles has a direct relationship with the heating rate and the temperature of calcination of the untreated RH, as well as potassium impurities [8].