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Silica from Rice Husk: Value Addition to Agro-wastes

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Sri Lanka rice cultivation occupies 34 percent of the total cultivation area and produces about 1.5 to 3 million metric tons per year depending on the weather condition according to the data from rice research and development institute and the department of census and statistics in Sri Lanka. Once rice is processed the major waste is the rice husk (RH). In general, 20 percent of raw rice grain contains husk. At present RH is used in different fields such as alternative fuel, bio-fertilizers, absorbent in building materials and material for animal husbandry. However, the amount of RH used in such industries with respect to the total production is very small. Consequently more often RH dump in to landfills. Burning of RH can get good amount of energy owing to its high calorific value of about 16000 joules per gram. Even after combustion at high temperatures it generate ash, which accounts about 20 percent of the RH. Rice husk ash (RHA) contains about 90 percent silica with trace amount of other metal oxides. If we follow the above statistics, the total rice production of Sri Lanka per year produces about 300,000 to 600,000 metric tons of RH. If one assume 50% of such RH is burned it generates about 30,000 to 60,000 metric tons of RHA. Since it contains about 90% silica, it is possible to produce 27,000 to 54,000 metric tons of silica per year. This could be even doubled if all the RH is utilized. Thus, extraction of silica from RHA would be a great value addition to rice industry as well as a solution for the waste management which impact environment positively. Further this provides new business opportunity to generate additional revenues from the waste.

Silica is one of the multipurpose chemical compounds that exist in gel, crystalline and amorphous forms. The major industries where silica uses are rubber industry especially the tyre manufacturing, pharmaceuticals, cosmetics, paints, printing tonners and so on. Conventional silica production method is based on the reaction between sodium carbonate and quartz at high temperatures. However, the processes involved in traditional method are energy intensive. Considering the abundance and cheap cost as agro waste RHA, many researchers and industrialist especially in other paddy cultivation countries have focused their efforts on the possible uses of RHA to extract the silica. Being biogenic origin the author and his research team believes that the silica extracted from RHA has a high value with respect to the chemically synthesized silica. At present the author and his research team extensively studies the cheapest and most effective ways to extract silica form RHA. Further, conversion of such silica into nanosilica and surface modifications of silica to make them compatible in rubber matrices are also being investigated. In this brief, the chemical process involves in silica extraction from RHA is discussed.

Rice husk ash in fully burned condition contains high amount of silica. Thus, selection of ash is important as
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the quality of ash determines the yield as well as the quality of end product. If it fully burned at high temperature for long time it appears as white-grey in colour as shown in Figure 1.a, with comparison to the black-coloured ash obtained from incomplete combustion as shown in Figure 1.b.

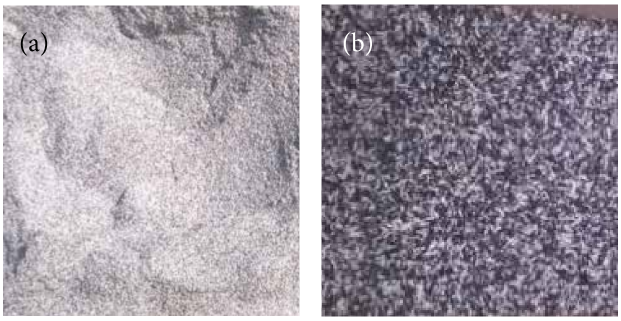

Figure 1. Colour of the a) well burned RHA and b) incomplete burned RHA

We experienced that unburned contents and remaining carbon in the ash hampers the silica digestion as well as the impurity level in the final yield. Thus mechanical sieving of the RHA an obtaining particles size below 125 µm mesh gave a better characteristics in the end product. In general, the extraction of silica by chemical method involves the dissolving of silica in sodium hydroxide followed by precipitation by acidifying the medium. The initial reaction of extraction of silica from ash as sodium silicate using caustic soda is given below.

$$\underset{\text{(ash)}}{SiO_2(s)} + \underset{\text{(caustic soda)}}{2NaOH(aq)} \rightarrow \underset{\text{(sodium silicate)}}{Na_2SiO_3(aq)} + \underset{\text{(water)}}{H_2O(l)}$$

Above reaction needs high temperature and mechanical agitation. However, the temperature depends on the quality of the ash selected. After couple of hours slurry is obtained which can be decanted off to get the slightly yellowish colour sodium-silicate solution. The intensity of the colour depends on the dissolved impurities present in the medium. The next step of the process is the precipitation of silica from sodium silicate solution using an acid. Sulfuric acid or mixture of sulfuric acid with hydrochloric acid is commonly used. However, sulfuric acid is very expensive and consequently any process involves sulfuric is too costly. Thus, possibility of using carbonic acid for the precipitation of silica is being currently investigated. The preliminary result shows that it can be effectively used. If this method is success, the carbon dioxide evolve in the combustion of RH can be effectively used which will dramatically reduce the production cost. The reaction of precipitation of silica from sodium silicate solution with addition of sulfuric acid is shown below.

$$\underset{\text{(sodium silicate)}}{Na_2SiO_3(aq)} + \underset{\text{(sulfuric acid)}}{H_2SO_4} \rightarrow \underset{\text{(silica)}}{SiO_2(s)} + \underset{\text{(sodium sulphate)}}{Na_2SO_4(aq)} + \underset{\text{(water)}}{H_2O(l)}$$

The silica is formed as a gel. This could be dried in a conventional oven or spray dried. This silica has metal oxides as impurities. Washing this product with hydrochloric acid and successive washing with demineralized water will do further purification. The conductivity of the effluent can be easily used to evaluate the purity of the final product. The X-ray diffraction pattern of before and after purification is shown in Figure 2. The broad halo without sharp peaks of the purified silica confirms the amorphous nature of the extracted silica and the effectiveness of the process.

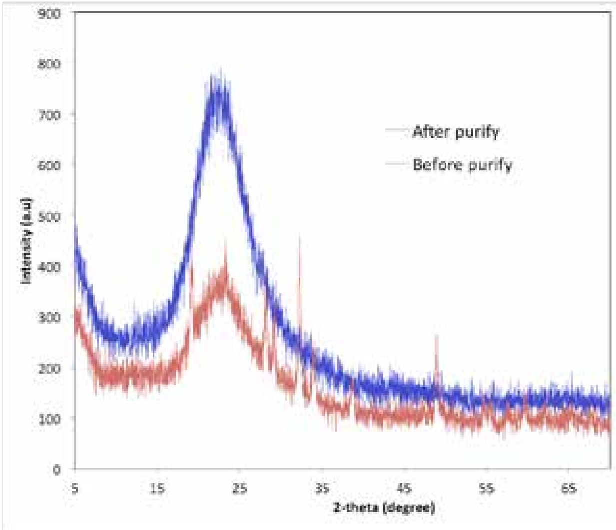

Figure 2. X-ray diffraction patter on unpurified and purified silica extracted from RHA

Depending on the type of acid used there are associated recoveries. For example if sulfuric acid is used sodium sulphate is a by-product. By evaporation of water, followed by crystallisation, filtration and drying, crystals of sodium sulphate can be obtained. Sodium sulphate has multiple uses. If carbonic acid is used sodium carbonate can be obtained as a by-product. In addition to these in the first step activated carbon can be generated if our RHA contains unburned carbon. This activated carbon may be used in purification of industrial effluents. Thus, the major product as well as all the by-products of this process has a commercial value and have a high demand in the market. This kind of value addition to agro-waste can reduce the pollution to great extent. Further, this process does not generate any toxic effluents hence this process does not pollute the environment. There is also very attractive return on investment on the project.

Currently in Sri Lanka, no one is doing this value addition. If one metric ton of imported silica cost around $1000, Sri Lanka rice industry can save around 27 to 54 million US dollars per year. The opportunity to make profit from this agro-waste is still open up for the new and existing entrepreneurs.

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Role of Chemistry in Personalized Medicine

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Wellbeing of a person is a crucial factor in life which facilitates the performance of his or her day to day routine work in well-organized manner. However, it is a known fact that we all get sick and we need to take suitable medicines accordingly, as prescribed by clinicians. Even though millions of people are taking medications daily, they are found to be effective only on a part of the population who use them. Some drugs, such as 'statins' which are frequently used to lower cholesterol are known to be effective only on 1 in 50 patients. On the other hand, some drugs cannot be metabolized by some people leading to arouse toxicity and allergy on them. Thus, the importance of the identification of this personal difference in medication has now been considered in designing and prescribing drugs for different diseases, opening avenues to the new paradigm in medicine, '**personalized medicine (PM)**'. Hence, personalized medicine represents the alignment of medical treatments to the individual characteristics of each patient, which are determined by the genetic make-up or the genome of that particular patient. This new approach of medicine is based on the revelations on the correlation between person's unique molecular or genetic profile and certain diseases. Ultimately, PM can predict the safety and effectiveness of a medical treatment on each individual, enhancing the precision of the treatment based on the molecular profile of the patient, by reducing harmful side effects and ensuring the successful outcomes on the patient. Cancers including breast cancers and cardiovascular diseases are the prominent candidates to be treated using PM approach.

Personalized medicine relies on the interdisciplinary research not only to find out specific bio-markers to diagnose a disease or predict the risk of having it, but also to deliver targeted treatment to each individual or group of individuals suffering from the disease. In this regard, medicinal chemistry which overlaps with different disciplines of science, including organic chemistry, bio-organic chemistry, physical organic chemistry, biochemistry, pharmacology, toxicology, analytical chemistry, molecular biology and genetics play a major role to build up the bridge between chemistry and PM. Medicinal chemistry can greatly catalyze the process of drug discovery and development, with the collaboration of pharmaceutical industry to bring new medicines from bench to market. Not like in early ages, complex synthetic methods and technologies such as combinatorial chemistry (comb-chem), microwave assisted organic synthesis (MAOS) and high-throughput (HTS) biological screening methods are accompanied with new drug discovery programs which accelerate the process of discovery. Comprehensive knowledge of the synthetic chemistry, computational chemistry, and biology literature ultimately can propel the discovery forward until it passes to the end market. Finding of potential drug targets has now been enhanced by the knowledge of molecular biology, especially the information on human genome and proteome (total protein content of a given organism, tissue or a cell at a given time). Medicinal chemists use this information to identify relevant targets capable of being affected by the interactions with candidate drug compounds. This process is now been facilitated by different computational approaches, such as 'molecular docking', in which interactions between drug targets, especially protein molecules and drug molecules are predicted. Subsequently, those candidate drug molecules are short listed according to their effectiveness to choose the best candidates before proposing, synthesis and testing for direct action on protein targets, in order to effectively treat a wide variety of diseases. Herein, chemist can analyze the interaction of the drug with the wide array of target molecules which depends on the personal variation. Thus, he or she can modify the structure of the drug to be more suited for the particular patient or the group of patients.

Molecular biology in combination with computational chemistry, especially computer based drug designing has now enabled chemists to rationally design new drug molecules targeting the known bio-molecules. Compared to the traditional methods in developing a drug against a disease, this new approach saves time and allows for a more comprehensive understanding of the drug-target interplay. In this process, initially the major molecule/s which show/s the desired biological activity should be identified using new technologies such as HTS and combinatorial chemistry. Thereafter, those molecules need to be modified and optimized, by using structure-activity analysis (SAR) in order to improve the desired pharmacological properties
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