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AMORPHOUS MAGNESIUM SILICATE FROM RICE HUSK

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Abstract

Rice husk contains silica in molecular form which can be extracted as amorphous silica. Amorphous silica is highly reactive for many chemical reactions. Amorphous silica usually achieved under controlled burning conditions from siliceous agriculture wastes. Amorphous silica can be employed to synthesize magnesium silicate (talc) which is an important industrial chemical. In present study an attempt has been made to synthesize amorphous magnesium silicate from amorphous silica of rice husk and by using magnesium salts. Amorphous silica first recovered from rice husk under controlled burning conditions and then made to react with sodium hydroxide to produce sodium silicate which subsequently allowed to react with magnesium salts solutions. Magnesium silicate samples were prepared by using two magnesium salt solutions by varying their concentrations in the range of (0.5M-1.0M). Study was carried out to determine the best concentration of magnesium salt solutions for magnesium silicate. FTIR and XRD techniques were used to determine the formation and purity of magnesium silicate.

Key words: Amorphous magnesium silicate, Amorphous silica, FTIR, XRD

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1. Introduction

Rice husk ash is economical raw material for production of silica because of its abundant availability. Rice husk renders amorphous silica when calcined under controlled burning conditions such as proper circulation of air, temperature and length of time of smoldering [1]. Chemical composition of rice husk varies from sample to sample due to difference in type of paddy, climatic and geographical conditions. Approximately 20% silica is present in molecular form in protuberances and leaves of rice husk [2]. Applications of rice husk and rice husk ash has been extensively reviewed [3].

The ash of rice husk has been put to use for a wide variety of applications. Sodium silicate was produced from rice husk ash by allowing reaction between RHA and sodium hydroxide at boiling point of mixture in open and closed systems. About 90% silica conversion from the ash into sodium silicate was achieved in closed system at 120 °C [4].

Talc is a naturally occurring nonmetallic mineral which has the formula $H_2Mg_3(SiO)_3$, and corresponds to $3MgO.4SiO_2.H_2O$. The mineral occurs in ores which contain varying quantities of nonmetallic minerals such as serpentine, magnetite, calcite and quartz. Metallic impurities such as iron, nickel, bismuth and arsenic in the form of sulfides and mixed sulfides are present in some ores [5].

Magnesium silicate is a silicate salt of magnesium. The most common hydrated forms found in nature are asbestos and talc. The interesting trend in the production of highly dispersed silicate involves precipitation of sediments, particularly in the preparation of sodium silicate solution with solutions of selected salts [6].

Magnesium silicate may be used as a filler and pigment in dispersive paints, as an adsorbent in affinity chromatography, and as a component of anti-epileptic drugs. As far as whiteness is concerned, its white color may easily compete with titanate based pigments, which allows eliminate partially or totally titanium dioxide. It could be employed in the treatment of alimentary intoxication, indigestion, inflammatory conditions of the small intestine, gastric acidity and peptic ulcers. Magnesium silicate is also used in the production of confectionery as an anti-adhesive and anti-caking agent (molding powder or a component of anti glitter paste) [7].

Magnesium silicate exhibits strong sedimentation interactions in an organic medium such as linseed oil. The interactions increase with increasing amounts of applied modifying compounds, which improve physicochemical properties of the product. The surface of magnesium silicate carries free hydroxyl groups (silanol groups), which are the most reactive groups on the surface. They provide the site for physical adsorption of organic particles and easily react chemically with multiple substitutes. Being substituted with new atom groups, they provide potential for surface modification [8].

In the present study magnesium silicate is synthesized from rice husk with an objective is to have 99% pure form of compound which can be used in purification of edible oil, paper and other chemical industry.

2. Materials and methods

Pretreatment of rice husk involves the washing of rice husk with distilled water followed by drying for 24 hr at 105^{o}C. Calcination was done at 600^{o}C in muffle furnace for 2 hours followed by cooling, grinding and screening from 200 mesh sieve.

Sieved RHA was allowed to react with 1M solution of sodium hydroxide. 500 ml of 1M solution was treated with 100g of RHA at boiling point of the mixture. This process rendered sodium silicate solution of high purity.

Solution of sodium silicate was subsequently titrated with dilute solutions of magnesium chloride and magnesium sulfate by using phenolphthalein as an indicator. Analytical grade chemical reagents were used in the experiments. These Chemicals were NaOH (Merck), $MgSO_4.7H_2O$ (Merck), $MgCl_2.6H_2O$ (Merck), distilled water.

As a result of titration precipitates of magnesium silicate were obtained which were filtered in ordinary filter paper. The precipitates of magnesium silicates were dried in oven at 105^{o}C for 24 hours and followed by XRD and FTIR analysis.

3. Results and discussion

The silica present in rice husk can not be extracted by any chemical method. The only technique is to extract by calcinations under controlled temperature. The silica obtained by calcination technique was tested by XRD machine under set conditions. The XRD pattern obtained is shown in Figure 1 indicating amorphous nature of silica. The diffuse peak of pattern at 22 degrees represents the formation of amorphous silica [9]. This amorphous silica converted into sodium silicate as a result of reaction between amorphous silica and sodium hydroxide which was used to synthesize the amorphous magnesium silicate.

Various concentrations of magnesium chloride and magnesium sulfate were used to form magnesium silicate.The effect of concentrations on yield of magnesium silicate are shown in Fig.2. Figure2 indicates that the magnesium chloride yields more manesium silicate comapred to magnesium sulfate under same conditions. XRD analysis was carried out in Philips Model PANalytical X-pert pro-machine, using voltage of 35 kV and current of 35 mA intensity. XRD patterns obtained are shown in figures 3 and 4.

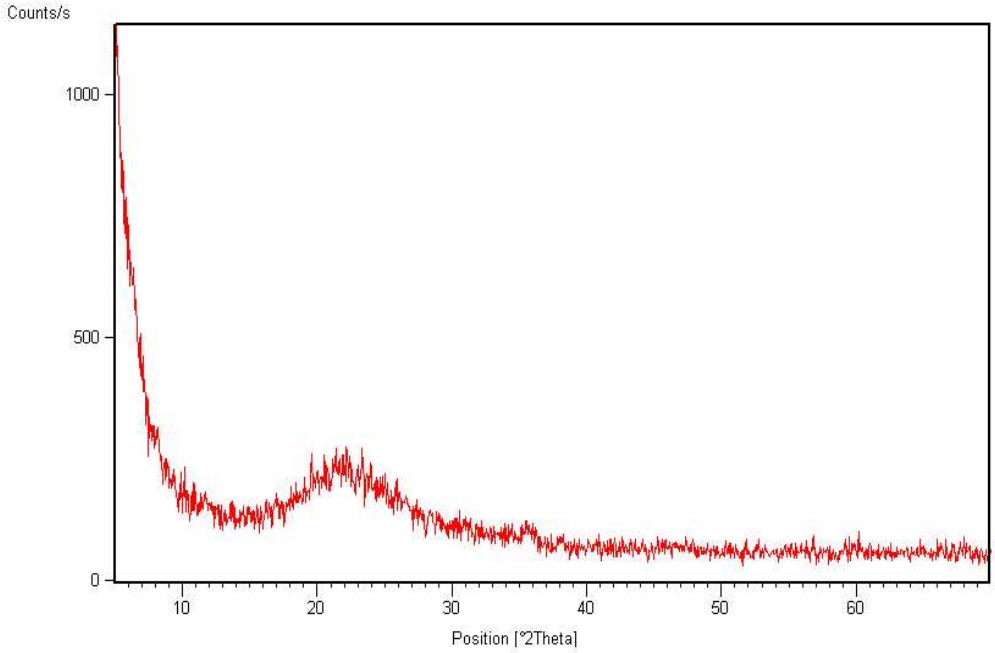

Fig1: XRD pattern of RHA

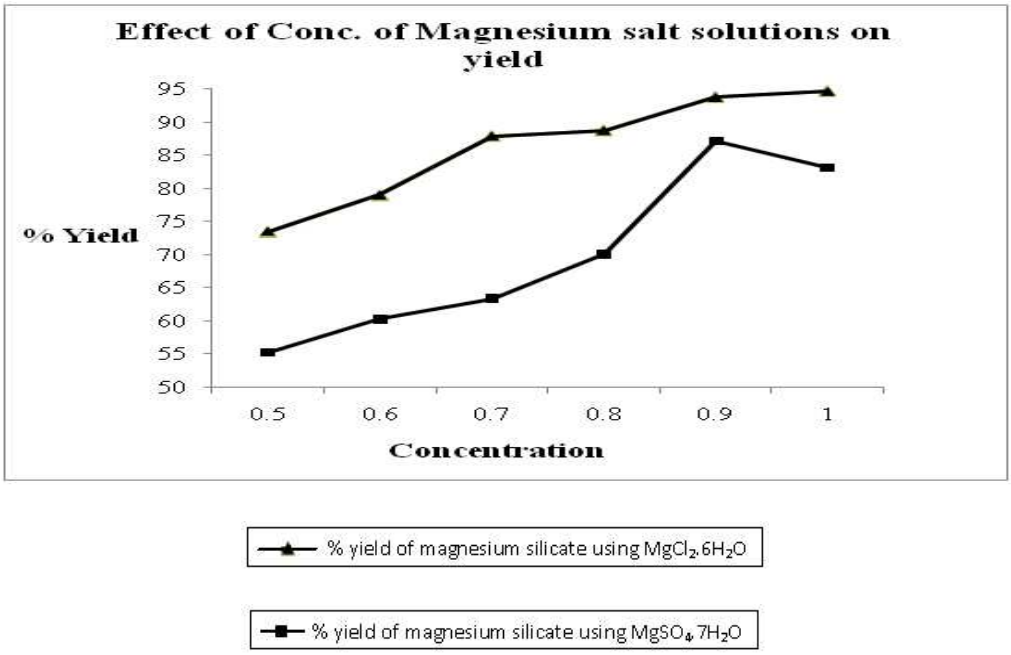

Fig. 2: Yield of magnesium silicate

Both XRD patterns of amorphous magnesium silicates shown in Figs 3 and 4 represent the amorphous nature of magnesium silicate because both patterns have diffused peaks at 22 degrees without having any short peak [9, 10]. It has been observed that varying the concentration of magnesium salts the quantity of amorphous magnesium silicate also varies but in each case the amorphous silica was obtained.

It has also been observed that by heating the amorphous silica in furnace up to 700 C the AMS converts itself into crystal magnesium silicate. By adding 4% borax in AMS and heating 1000 C the AMS completely melted and dissolved in borax. The melting point of AMS is 1350 C.

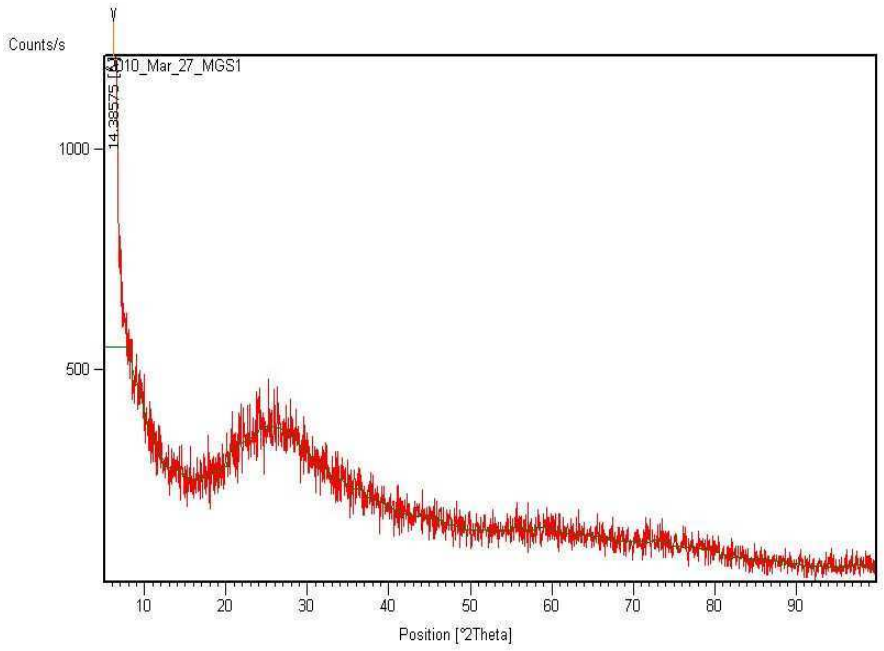

Figure 3: XRD pattern for amorphous Magnesium silicate using $MgCl_2.6H_2O$.

FTIR is another useful technique of detecting the compounds present in the sample. This technique was used to find out any other compound present in the samples.

Pure KBr was ground into powder along with the desired sample and a tablet was made by placing it in a die Pellet was ejected and placed in the sample holder inside the FTIR sample chamber. The machine was turned on and spectrum measurement was done. FTIR spectrum is a graph with wave number on x- axis and % transmittance on y-axis. Various peaks are there in the spectrum, which correspond to specific compounds or functional groups present in the sample. General pattern of both magnesium silicates shown in Figures 5 and 6 are similar.

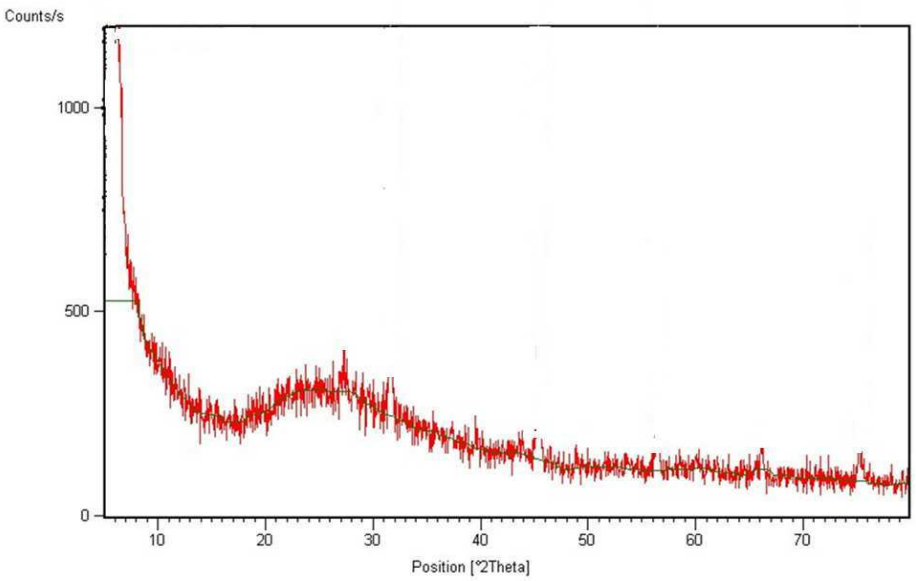

Fig 4: XRD pattern of magnesium silicate using $MgSO_4.7H_2O$

In the range of 500 to 1000 cm^{-1}.in case of magnesium sulfate other compounds were detected whereas in case of magnesium chloride no compound other than magnesium silicate was detected. can be concluded that using magnesium

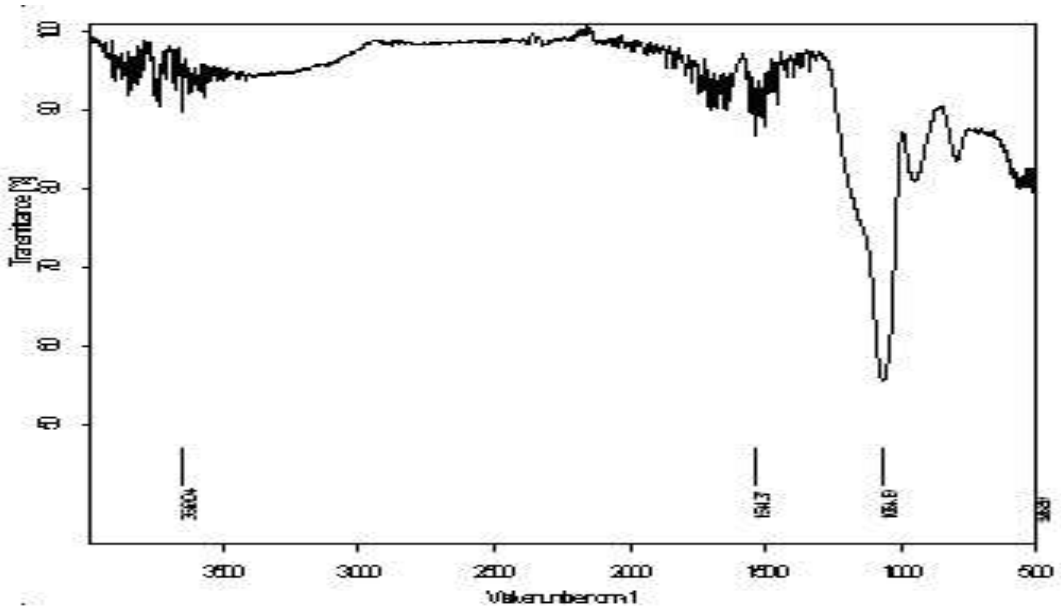

Fig. 5: FTIR of magnesium silicate (from magnesium Chloride)

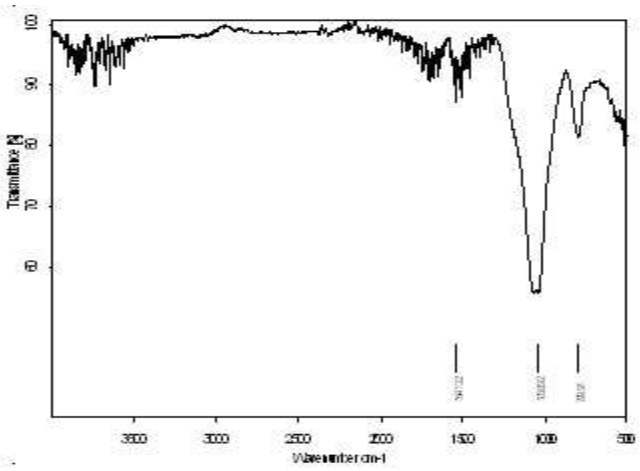

Fig. 6: FTIR of magnesium silicate (from magnesium sulfate)

Comparing all above figures and results it can be concluded that using magnesium chloride salt the magnesium silicate produced was truly amorphous and 99% pure.

4. Conclusions

It is possible to produce amorphous silica from rice husk under controlled burning conditions.

Amorphous silica obtained from rice husk can be utilized to produce amorphous magnesium silicate. Both magnesium salts i.e. magnesium sulfate and magnesium chloride can be used to obtain amorphous magnesium silicate. 99% pure amorphous magnesium silicate can be obtained from magnesium chloride.

Acknowledgement

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References

[1] Rizwan S.A. " High Performance Mortars and Concretes Using Secondary Raw Materials", PhD thesis 2006.

[2] Khangaonkar, P.R.; Rahmat, Azmi., "Kinetic Study of the Hydrothermal Reaction Between Lime and Rice-Husk-Ash Silica", Cement and Concrete Research, v 22, n 4, Jul, 1992, p 577-588

[3] Hasparyk, Nicole P.,"Effect of Silica Fume and Rice Husk Ash on Alkali-Silica Reaction", ACI Materials Journal, v 97, n 4, July/August, 2000, p 486-492

[4] Edson Luiz Foletto, Ederson Gratieri, Leonardo Hadlich de Oliveira, Sérgio Luiz Jahn., "Conversion of rice hull ash into soluble sodium silicate", Mat. Res. vol.9 no.3 São Carlos July/Sept. 2006.

[5] Rozainee, M.; Ngo, S.P., "Effect of Fluidizing Velocity on the Combustion of Rice Husk in a Bench-Scale Fluidized Bed Bombustor for the Production of Amorphous Rice Husk Ash", Bioresource Technology, v 99, n 4, March, 2008, p 703-713

[6] Krysztafkiewicz, R.Werner, L.K. Lipska., T. Jesionowski., "Effect of saline coupling agents on properties of precipitated sodium- aluminium silicate", Journal of Material Science., 23, 2001, pp: 65-81

[7] D. R. M. Brew and F. P. Glasser., "Synthesis and characterisation of magnesium silicate hydrate gels", University of Aberdeen, 033 Meston Building, Aberdeen AB24 3UE, Scotland, UK. 2004.

[8] Skrifvars, Bengt-Johan ., "The Fouling Behavior of Rice Husk Ash in Fluidized-Bed Combustion.",. Fuel characteristics. Energy and Fuels, v 19, n 4, 2004, pp 1203-1220.

[9] Proctor, A., "X-Ray Diffraction and Scanning Electron Microscopic Studies of Rice Hull Ask", JAOCS, pp 815-837, 1990.

[10] Kalapathy U., Proctor A. and Shultz J.,"A simple method for production of pure silica from rice hull ash", Bioresource Technology, Vol. 73, (2000), pp 257 264