Investigation of Possibility using of rice husk as desiccant materials

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Abstract: - Replacing chemical desiccants such as silica gel with natural fibers and agricultural wastes not only provide the sustainable materials, but could also solve environmental problems vis-à-vis these materials. In this study, the potential of using Rice Husk and its treated forms with alkali solution as a desiccant material has been investigated. The bare RH and treated RH have been characterized using FTIR, XRD, DSC, and SEM. The ability of water absorbance for the prepared samples has also been compared. The results revealed higher water absorbance of alkali treated RH compared to the bare RH. Currently, the work is focused on determining superior treatment conditions of treating RH involving more characterization methods.

Key-Words: - Agricultural wastes, Alkali treated, Desiccants, Rice Husk, Treated Rice Husk, water absorbance.

1 Introduction

Desiccants act as moisture absorber in order to dry their surrounding environments. Drying mitigates the hazardous side effects of moisture, such as corrosion, swelling, and the development of rust, mold, mildew, and fungus. Desiccants are used in electronics, food, shipping, sailing, tools, travel and relocation, and desiccant cooling systems. Numerous materials have been utilized as desiccants to absorb different types of liquids. Although more and more are of synthetic and inorganic in nature, certain types are composed of natural ingredients, such as plants. The absorbent properties of desiccants differ, and they react differently to diverse environments. Some desiccants exhibit greater affinity with oil than with water or other types of liquid materials. The majority of these materials are expensive, which prompts researchers to identify new and more economical materials [1-4]. Various researchers have also studied the environmental impact of these desiccants [2]. Replacing chemical desiccants, such as silica gel and molecular sieves with natural fibers is a novel and sustainable alternative. High-fiber agricultural wastes are potential candidates as desiccants for use in desiccant-dehumidification wheels. Ziegler et al. proposed the use of grains as desiccants in a solar-drying storage system, utilizing the deep-bed drying model [1]. Williams et al. [2] experimented with the use of kenaf core as a desiccant, and compared it with silica gel to determine the suitability of the former as a packaging desiccant. Starch was determined to be suitable for industrial, commercial, and residential applications [4]. The same researchers studied the use of coconut coir as a desiccant in an engineering process[5]. There is a large quantity of agricultural wastes such as rice husk (RH), coconut coir, etc. which can be effectively utilized for a sustainable approach. About 20% of the whole rice in the rice milling industry ended up with the production of RH as its by-product. [6]. RH contains an unusual amount of silica compared to all other biomasses. In this study, the possibility of using rice husk and its treated form as a desiccant material has been investigated.

2 Experimental Procedure

Rice husk was collected from a local rice mill during milling season. The rice husk was first washed with deionized water and dried in an oven at 105 °C for 24 hours. The clean and dried rice husks were treated by soaking it in 1.0% (W/V) KOH solution at 100°C for 3 hr (50g rice husk in 500mL alkali solution). It was then left overnight to dry, and later filtered. The filtrated rice husks (first) were washed by HCl 0.1% (W/V) solution and later washed with plenty of distilled water until it was neutralized (pH = 7). The precipitate was then dried in the oven at 105 °C for 12 hours.

3 Characterization

The physical appearance of untreated rice husk was seen to be brownish in color prior to treatment. After treatment, it was seen to be light-yellowish in color (See figure 1).

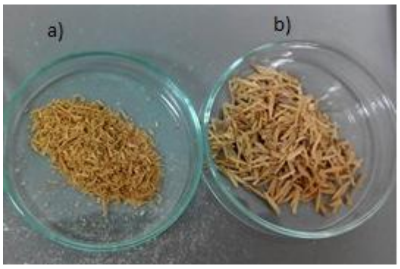

Fig. 1, (a) RH after treatment at 80°C for 4 h, RH as received without treatment (b)

Table 1 lists the chemical compositions of RH (before and after treatment) as determined by X-ray fluorescence (XRF) analysis.

Table 1, Chemical compositions of RH before and after treatment as determined by XRF (mass%)

Chemical Composition %	RH (before treatment)	RH (after treatment)
SiO2	89.14	59.79%
Al_2O_3	0.29	3.22%
Fe_2O_3	0.28	5.58%
CaO	0.95	0.03
MgO	0.42	0.35
Na_2O	-	1.59
K_2O	4.79	2.65
SO_3	1.18	3.56
P_2O5	1.31	0.71
Cl	1.28	9.45
MnO	0.16	0.15
WO3	0.11	0.86
CoO	0.04	9.56
ZnO	0.03	0.39
CuO	-	2.23
TiO2	-	0.40
Pd	-	0.30
Ru	-	

Alkali treatment caused substantial chemical degradation of hemicelluloses, lignin, and part of the crude fibers in rice husks. The usage of 1.0% KOH eliminated lignin and hemicelluloses in alkali-treated agricultural fibers. However, it is also believed that lignin is capable of retaining its structural stability[7]. The results of chemical content analysis have demonstrated that lignin was degraded during alkali treatment, and in any case, some researchers posited that Lignin content dropped by 96% as the concentration of NaOH was increased at the same rate [8] . Albano et al. [9] used 18% NaOH, while and Rajulu et al. [10] used 2% NaOH, and both confirmed the elimination of lignin and hemicelluloses in alkali-treated agricultural fibers. The crystallinity analyses of the samples were conducted using Bruker DB-Advance X-ray Diffractometer (XRD), Germany. Figure 2 shows the XRD diffractogram of treated RH. The X-ray diffraction (XRD) pattern of treated RH was mainly more crystalline silicon oxide phase diffused in both sharp peaks. Other studies mentioned the presence of [11] a strong peak at about 21.83º 2θ angle. It can be seen that peak at Theta = 21.83 degrees, confirming the formation of crystalline silica and a little amourphous silica, with the second sharp peak detected at about 15.71º 2θ with the same specification as well. Figures 3 shows the scanning electron micrographs of the outer surfaces of untreated rice husks and rice husks treated by 1.0% KOH solutions. Scanning electron microscope was used to study the surface roughness of untreated and treated rice husks. The results showed that the outer surface of untreated rice husks is quite rough. The roughness of the outer surface is represented by the asperities (Figure 3(a)). However, the asperities were almost removed from the surface after treatment in 1.0% KOH solutions (Figure 3(b)). The effects of alkali treatments on the change of surface roughness of various agricultural fibers are widely acknowledged [12]. FESEM of Rice husk show a regular well-defined layered structure (Fig. 3), which agrees with previous study observed in vermiculite and other phyllosilicates [13]. It seems that the alkali treatment of rice husk cannot destroy the inherent structure of the husk. KOH treatment removes the SiO_2, leaving behind the fibrous organic material. Alkali treatment led to formation of holes on the rice husk, and as part of the SiO_2 is in intimate contact or bonded to the organic molecules, some silicon remains intact. The functionality groups of the samples were determined using FTIR spectra, with the results being depicted in Figure 4. Four bands represents bare and treated rice husk. Bands

1041 cm^{-1} and 793 cm^{-1} are related to O-Si-O stretching vibrations. Also, in treated rice husk, the band 1659 cm^{-1} belongs to C-O group, while the bands at 3333 cm^{-1} are due to the chemisorbed water and surface hydroxyl groups. Bands 1023 cm^{-1} and 897 cm^{-1} are related to O-Si-O stretching vibration. Differential scanning calorimetry measurements (DSC) were carried out under nitrogen, with a Thermal Analyser Instruments (Figure 5). The peak in 81.56 °C belonged to the removal of water, the temperature of melting showed at 348.75 °C, and the peak in 427.50°C is due to temperature of crystallization. Water absorption is another physical property that is being considered. In this case, the water absorption (%) increased with the treatment of rice husk. Characteristics of the hydroxyl group of RH are responsible for the water absorption. The detailed measurement is currently being conducted.

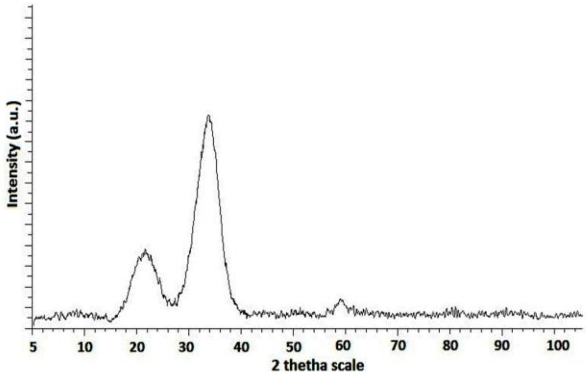

Fig. 2, XRD patterns of RH treatment

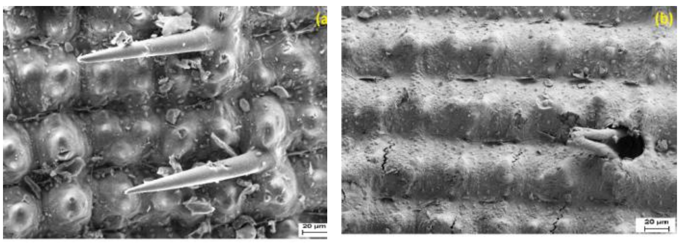

Fig. 3 FESEM photographs of a) bare rice husk b) alkali treated rice husk

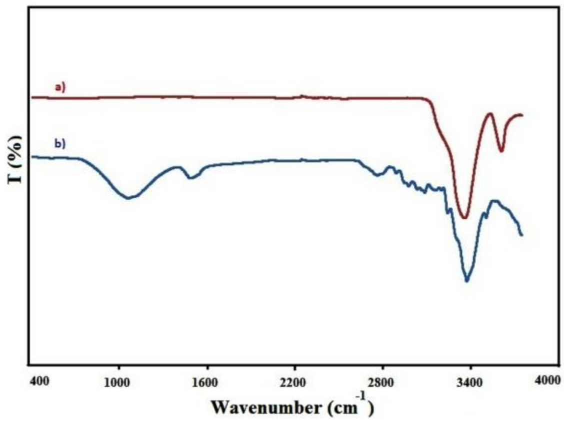

Fig. 4 FTIR spectra a) rice husk b) alkali treated rice husk by 1.0%KOH

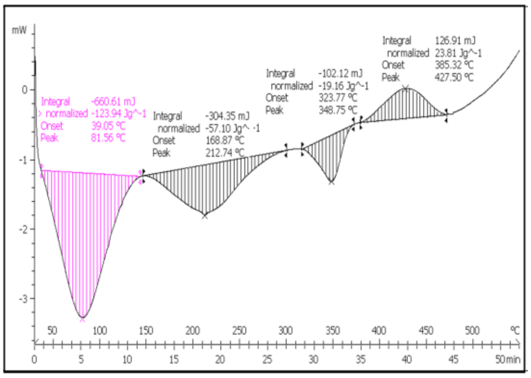

Fig. 5 DSC of alkali treated rice husk by 1.0%KOH

4 Conclusion

The initial findings in this research revealed that agricultural wastes have the potential to be used as a desiccant instead of chemical desiccants. Its granular structure, insolubility in water, chemical stability, high mechanical strength, and local availability at almost no cost of Rice husk (RH) make it popular agriculture waste for investigation. The advantage in using these adsorbents in certain critical application is the fact that there is no need to regenerate them due to their low production costs. Rice husk treatment performed well compared to untreated rice husk. In addition, using agricultural wastes provide additional value by preserving our environment, reducing the carbon emission, and promoting sustainable products. It should also be pointed out that prior to the general application of a proposed new concept, detailed studies involving the determination of superior treatment condition and optimization of the procedure, investigating the life cycle of the rice husk (adsorption-regeneration), and the quality of air leaving the bed, must be conducted beforehand. Desiccant systems using waste materials consume less energy than systems using chemical desiccants.

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