Investigating Properties of Rice Husk for Contaminant Removal from Polluted Water

T.D.K. De Silva
Uva Wellassa University, Badulla, Sri Lanka

and

K.G.N. Nanayakkara
Institute of Fundamental Studies, Hantana Road, Kandy

Introduction

Contamination of ground and surface water by different pollutants is a major environmental problem. These pollutants are discharged by sources such as industries into natural water streams. Water pollutants are toxic to most aquatic organisms, human body and may cause denaturing of protein, tissue erosion, and paralysis of the central nervous system and also damage the kidneys, liver and pancreas. Most of the pollutants are toxic even at very low concentrations. Therefore, designing effective strategies to remove pollutants from water is of practical interest (Zhang *et al*., 2011).

Utilization of one waste material to control pollution caused by another is of high significance in the remediation of environmental problems. Rice husk is an abundantly available agricultural waste. The compositions of rice husk are 32% cellulose, 21% hemicellulose, 22% lignin and 15% mineral ash (Nakbanpote *et al*., 2007). Rice husks can be used as a low cost adsorbent (Tarley and Arruda, 2004). This research aimed to chemically modifying surface properties of rice husk to be used in waste water treatment. It would help to increase the volume of purified consumable water.

Methodology

Rice husk ash was prepared by heating rice husk at 500 ^{0}C for 2 hours in box furnace. Subsequently, it was reacted with CH_3COOH (1M, 24 hrs, 1g/10 mL, Room Temperature) to made surface modified rice husk ash. Their physical and chemical properties were determined by using Fourier transform infrared (FTIR) spectrum, zero point charge (pH_{ZPC}), zeta potential, methylene blue method and Boehm titration method.

Results and discussion

FTIR Spectra study

The FTIR spectra are virtually identical (Table 1). Since, -COOH groups are originally contain in rice husk, FTIR spectra of modified rice husk ash does not show any new peak but some shifts can be seen. Therefore, we can not confirm about surface modification on rice husk based only on this analysis. Since the quantity of samples used in test were not the same, it is difficult to quantify the amount of new –COOH groups using obtained FTIR spectra alone.

Experimental results of the determination of pH_{ZPC} are illustrated in Figure 1 and 2. It was found that pHzpc values of rice husk ash before and after modification as 8.3 and 6.5, respectively. These data show that the pHzpc is more acidic after modification. Similar results were reported elsewhere in literature (Chen et al., 2003). Such decrease in pHzpc confirms the surface modification. Determination of pHzpc in aqueous solutions of different ionic strength gave nearly equal results (Figure 2). This finding shows that pH_{ZPC} does not depend on the ionic strength of the solution. The significance of this kind of plot is that a given material surface will have positive charge at solution pH values less than the pHzpc and thus be a surface on which anions may adsorb. On the other hand, that material surface will have negative charge at solution pH values greater than the zpc and thus be a surface on which cations may adsorb.

Based on Figure 3 and 4, specific surface area of the unmodified and modified rice husk is 0.52 m^2/g and 2.81 m^2/g, respectively. Considering zeta potential values, 8.29 mV increment can be shown after the modification. The results of Boehm titration clearly show that the acetic acid treatment has increased the amount of –COOH groups present in rice husk ash.

Table 1: FTIR spectrum values & functional groups for unmodified & modified rice husk.

Unmodified Rice Husk (cm^{-1})	Modified Rice Husk (cm^{-1})
3443.7	3447.9 → OH
1637.9	1639.2 → C=O
1094.4	1093.1 → Si-O-Si
799.6	801.8 → Si-H
463.4	467.1 → Si-H

Zeta potential study

The zeta potential of unmodified rice husk and modified rice husk were -44.50 mV and -36.21 mV at pH 7 buffer solution, respectively. An increment of 8.29 mV was obtained after the modification.

pHzpc study

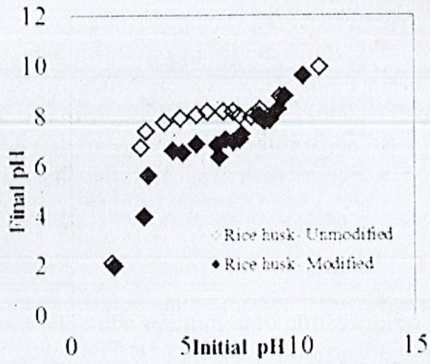

Figure 1: Determination of pH $_{ZPC}$ of unmodified rice husk and modified rice husk in pH solutions without ionic strength. (ZPC of unmodified rice husk= 8.3, ZPC of modified rice husk = 6.5)

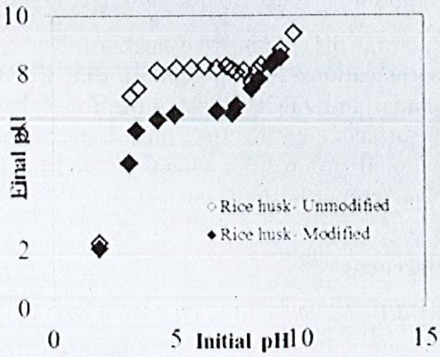

Figure 2: Determination of pH $_{ZPC}$ of unmodified rice husk and modified rice husk in pH solutions with 0.05 M $NaClO_4$. (ZPC of unmodified rice husk= 8.3, ZPC of modified rice husk= 6.7)

Quantitative determination of –COOH

Quantity of –COOH groups present in unmodified rice husk= 2.384 x 10-3mol/g, modified rice husk= 2.488 x 10-3mol/g.

Surface area determination

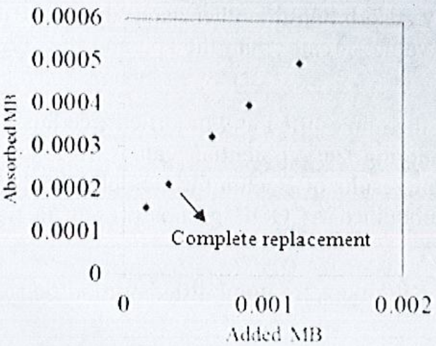

Figure 3: Determination of the point of complete replacement of cations from the titration curve of parent rice husk

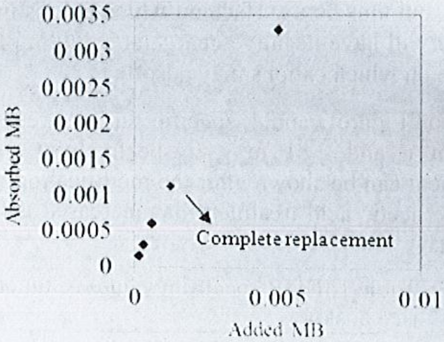

Figure 4: Determination of the point of complete replacement of cations from the titration curve of modified rice husk

Specific surface area of unmodified rice husk= 0.52 m^2/g, modified rice husk= 2.81 m^2/g.

Conclusions

The FTIR spectrum of modified rice husk was shifted slightly from the FTIR spectrum of unmodified rice husk. Considering those graphs it can be concluded that the rice husk ash and modified rice husk ash contain OH, C=O, Si-O-Si, and Si-H groups. The Zero Point Charge (pH_{zpc}) of modified rice husk using Batch equilibrium method was reported as 6.5 while the pHzpc of unmodified rice husk was 8.3. Introduction of ionic strength to the background electrolyte does not have significant impact on pHzpc.

At neutral pH, parent rice husk ash can adsorbs anions while modified rice husk ash can adsorbs cations. Zeta potential of modified rice husk was increased by 8.29 mV. So Zeta potential and ZPC values confirm the chemical modification. The modification improves the surface area of rice husk ash. Boehm titration shows the increment in –COOH functional group after chemical modification. The rice husk ash was modified and the surface properties have been changed.

References

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