A Novel Study on Using Vietnam Rice Hush Ash and Cullet as Environmental Materials

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Abstract. This work introduces novel method to prepare ecomaterials wollastonite ($CaSiO_3$) using the hydrothermal treatment technique of Rice hush ash (RHA), glass cullet and CaO at 180^oC for 24 hour so as the Ca/Si molar ration of 1.0. The sample after hydrothermal treatment at 180^oC for 24 hours is calcined at 1000^oC to obtained wollastonite $CaSiO_3$. The obtained wollastonite has many applications in biomaterials and thermal insulator. This research also aim to improve the quality of RHA, thus reduce negative impact to environment.

1 Introduction

Vietnam is an agriculture country, in which produce lot of rice and its by product is rice husk ash (RHA). The RHA is consider as waste of agriculture industry, and treated by burn in the open air. This process cause air pollution, thus attracted Vietnamese researcher to find alternative method to reduce the impact of rice husk ash to environment. The research group in Department of Ceramic Materials aim to reuse rice husk ash as source of Silica (SiO_2). It need to emphasized that the main content of rice husk ash is silica. In addition, glass cullet also contain up to 70% of Silica. This research report new technology to mixing RHA with glass cullet and CaO with the Ca/Si molar ratio of 1.0, in order to synthesize Wollastonite ($CaSiO_3$) as environmental materials. Compare with the other method to synthesize wollastonite using chemical reaction between CaO and SiO_2 at 1500^oC [1-7], the hydrothermal treatment technique require lower temperature. The advantage of our study is utilize the Vietnam RHA and reduce the

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2 Materials and methods

2.1 Preparation of RHA

Rice husk is burn at 600^{o}C with the heating rate of 10^{o}C/min (Naberthem 1400, Nabertherm, Germany), then soaking at 2 hour for complete burning. The phase composition of obtained RHA is characterized using Xray Diffraction and Fourier transform infrared spectroscopy (FTIR).

2.2 Preparation of glass cullet

Glass cullet is supplied by Coca Cola Vietnam. The cullet is pre-milled by hammer milling, then heating at 700^{o}C using electric furnace (Nabertherm 1400, Nabertherm, Germany) with the heating rate of 10^{o}C/min, soaking at 30 min, quench by tap water to increase the milling ability. The cullet is milled in ball milling machine for 20 mins, and pass the sieve 125 μm. The chemical composition of obtained RHA is characterized using XRay Flouresence (XRF) method.

2.3 Preparation of CaO

CaO is supplied by Xilong Chemical in bottle 500g.

2.4 Preration of mixture

The mixture of RHA, glass culled and CaO is mixing with the weight ratio of CaO: RHA: glass cullet is 1.43: 1.00: 1.00 so that the Ca/Si molar ratio of the mixture is 1.0 according to the chemical composition of wollastonite (CaSiO3). The obtained mixture is pressing at 25kG/cm^2 to form the disk the diameter of 14mm and height of 5mm, following by hydrothermal treatment at 180^{o}C for 6, 12 and 24 hours. The hydrothermal treated disk is calcination at 1000^{o}C (Nabertherm 1400, Nabertherm, Germany) to form wollastonite.

2.5 Phase analysis

The powder Xray Diffraction (XRD) patterns of disk samples were recorded with a vertically mounted diffractometer system (Bruker-AXS: D8 ADVANCE, Germany) using Ni filtered CuKa generated at 15 kV.

2.6 The morphology of samples using Scanning Electron Microscope (SEM)

The surface of samples were observed using a scanning electron microscope (SEM) (JSM 5400LV, JEOL Co. Ltd., Japan) under an accelerating voltage of 20 kV after being coated with gold.

2.7 Chemical bonding of sample is analyzed by Fourier Transformer Infrared (FTIR)

The sample is mixing with KBr with the ratio 1: 200 and put in the FTIR machine with the waveband vary from 400-4000cm-1.

2.8 Chemical composition of sample is analyzed by Xray-Fluorescence (XRF)

The sample is energy using Xray (MESA-50, Horiba, Japan) and measure the secondary beam to analyze the chemical composition of sample.

3 Results and discussions

The chemical composition of RHA is shown in Table 1:

Table 1. The chemical composition of RHA (weight percent)

SiO_2	K_2O	CaO	P_2O_5	MgO	Al_2O_3	MnO	Fe_2O_3	SO_3	other	LOI	Total
92,7	3,16	1,33	0,596	0,466	0,306	0,291	0,242	0,126	0,153	0,63	100

The phase analysis of RHA is shown in Fig. 1. The main phase compostion of RHA is Cristoballite (SiO_2) at 2theta = 22°, as shown in Fig. 1

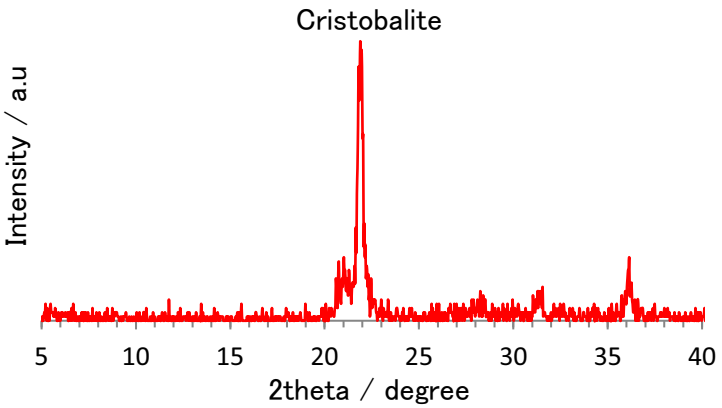

Fig. 1. XRD pattern of RHA, confirm the present of cristobalite at 2theta = 22°

The chemical bonding of RHA is shown in Fig. 2. This data confirm that the main chemical bonding of RHA is Si-O bonding.

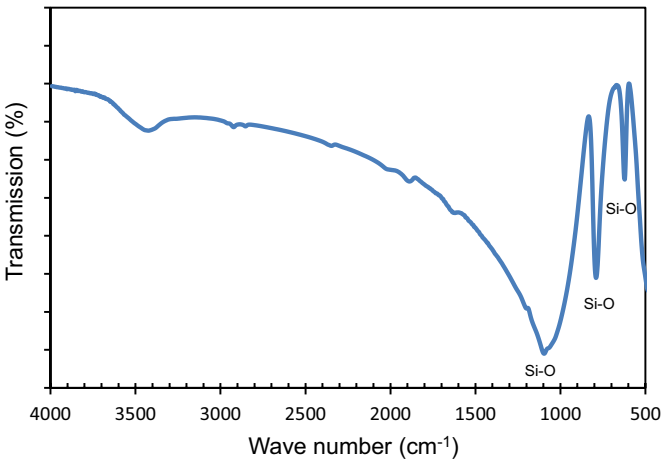

Fig. 2. FTIR of RHA. The bonding of Si-O is display on the figure at 600, 700 and 100 cm^{-1}

The chemical composition of glass cullet is shown in Table 2:

Table 2. The chemical composition of glass cullet (weight percent)

CaO	SiO_2	Al_2O_3	Fe_2O_3	MgO	Na_2O	K_2O	P_2O_5	TiO_2	LOI	Total
10,48	70,2	1,75	0,11	0,75	13,71	0,58	0,03	0,28	2,11	100

The SEM of sample hydrothermal treatment at different treatment time (0h, 6h, 12h and 24h) is shown in Fig. 3. We can observe new crystal interlock together at Fig. 3 (c) and (d) to enhance the setting property of sample.

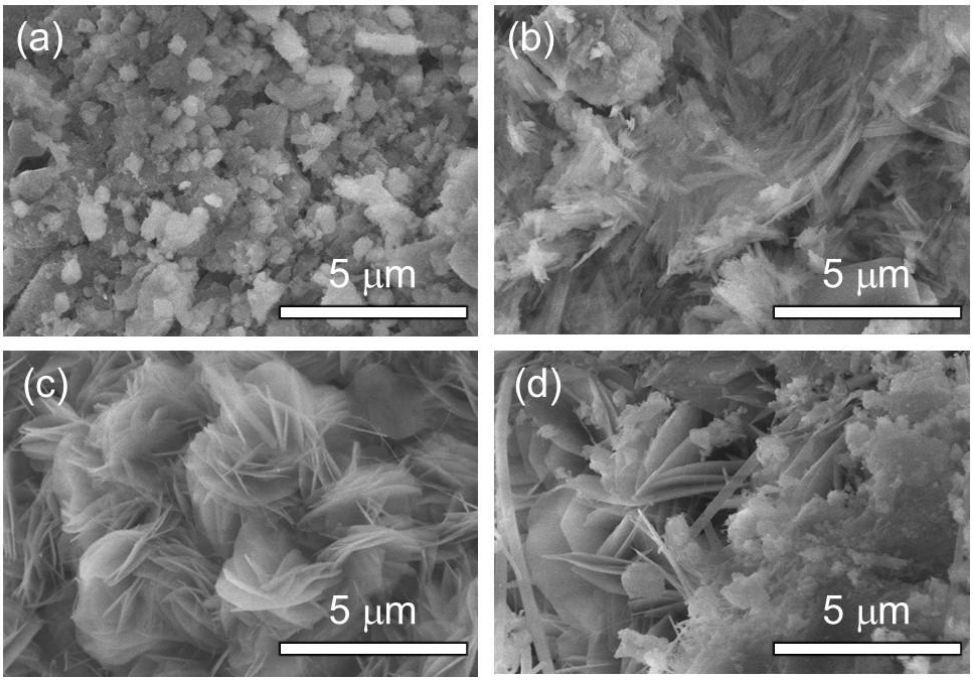

Fig. 3. SEM morphology of mixture hydrothermal treatment at 180^{o}C for (a) before (b) 6h (c) 12h and (d) 24h.

The XRD of sample hydrothermal treatment at different treatment time (0h, 6h, 12h and 24h) is shown in Fig. 4. After hydrothermal treatment, we can observed the peal of Tobermorite at 2theta = 29^{o}.

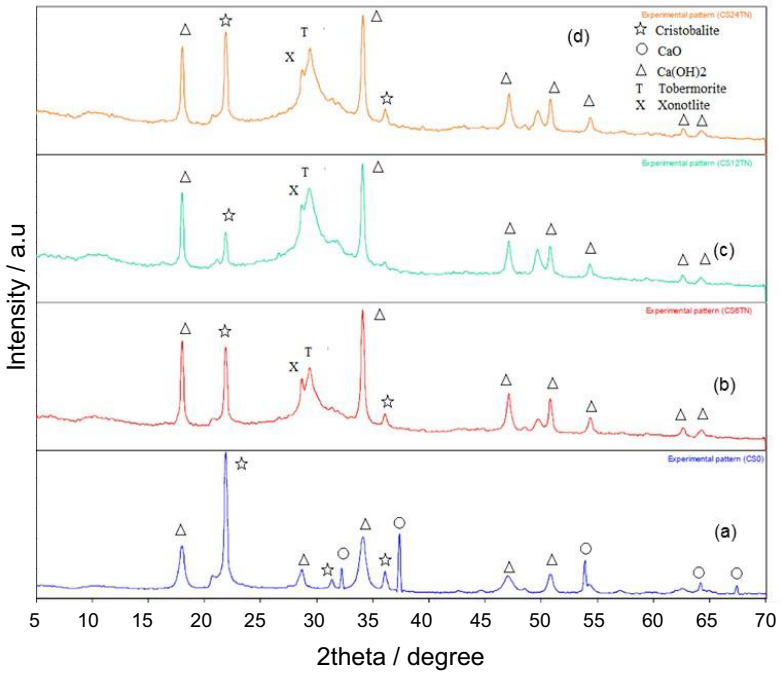

Fig. 4. XRD pattern of sample hydrothermal treatment at 180°C for different treatment time: (a) before; (b) 6h; (c) 12h and (d) 24h

The sample hydrothermal treatment at 180°C for 24h is calcinated at 1000°C to obtain the wollastonite. XRD of wollastonite obtained is shown in Fig. 5.

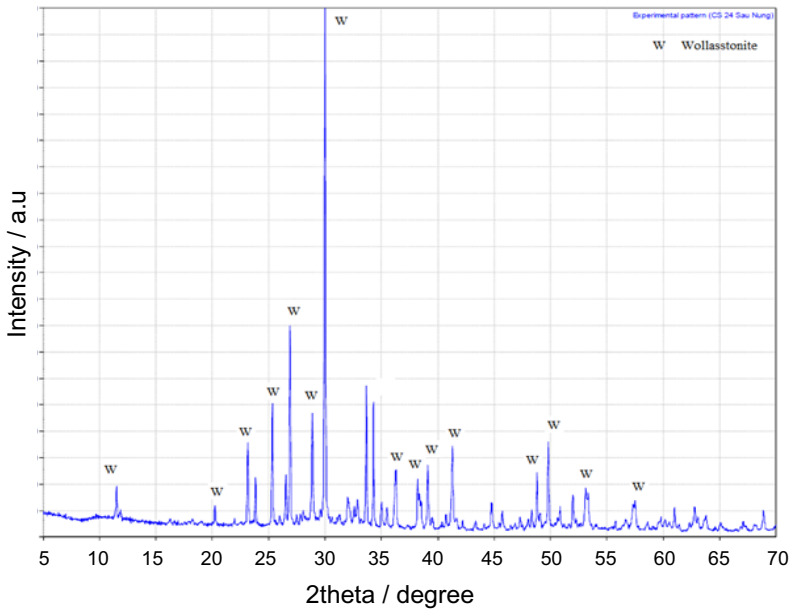

Fig. 5. XRD pattern of sample hydrothermal treatment at 180°C for 24h then calcination at 1000°C to obtain wollastonite (W:Wollastonite).

Figure 5 shows that we can obtain wollastonite by calcination hydrothermal treatment sample at 1000^{o}C. The meaning of the study need to put in to the context of our facility. By using hydrothermal treatment of RHA, glass cullet and CaO, following by calcination, we can obtain the wollastonite at 1000^{o}C. This temperature is much lower than the conventional method. For example, the solid reaction between CaO and SiO_2 to form wollastonite requires the temperature of 1500^{o}C or above to happen. The reason that we can lower temperature to form wollastonite from 1500^{o}C to 1000^{o}C is we utilize the hydrothermal treatment technique. In the other hand, this research is contributing to improve the quality of RHA, thus reduce the negative impact to environment.

4 Conclusions

By using hydrothermal treatment technique of mixture of RHA, glass cullet and CaO, following by calcination at 1000^{o}C, my research group can obtain wollastonite (CaSiO3) at low temperature. The obtained wollastonite has many applications in biomaterials and thermal insulator. This research also aim to improve the quality of RHA, thus reduce negative impact to environment. Further application of wollastonite in biomaterials is still under investigated by my group.

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