Comprehensive Study on Structural Properties of Zn_2SiO_4 Glass Formation Derived from Waste Rice Husks

Rahayu Emilia Mohamed Khaidir[a], Yap Wing Fen[a, b,*], Mohd Hafiz Mohd Zaid[b], Nur Alia Sheh Omar[a]

[a]*Functional Devices Laboratory, Institute of Advanced Technology, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia*

[b]*Department of Physics, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia*

**Corresponding Autor's Email: yapwingfen@upm.edu.my*

Abstract: Combination of zinc oxide and white rice husk ash ($ZnO_{0.60}$ – $WRHA_{0.40}$) were prepared to produce zinc silicate glasses (Zn_2SiO_4) by conventional melt and quench technique at 1450 ˚C. X-Ray Fluorescent (XRF) results were being analyzed to confirm the chemical composition presents in WRHA sample. The glass behaviors were investigated using X-Ray Diffractometer (XRD). XRF shows that WRHA contains about 90% of silica dioxide (SiO_2) while XRD shows that the glass amorphous nature phase was formed at composition of ($ZnO_{0.60}$ – $WRHA_{0.40}$). FESEM shows clear glassy surface which indicates the amorphous glass phase.

Keywords: *Zinc silicate glasses, solid state method, white rice husk ash, XRF, XRD*

INTRODUCTION

In recent developments, many researches on silicate phosphor as a host material have been conducted and numerous practical applications have been developed such as white light emitting diode (LED), sensor, lasers, amplifiers and optical data storage [1]. Phosphors based on this material are usually low-cost, chemically and physically stable. In this study, a combination of zinc oxide, ZnO with silica dioxide, SiO_2 is needed as starting materials to synthesize the zinc silicate glasses. Zinc silicate (Zn_2SiO_4) have been used as the main host material to exhibit luminescent properties due to its large band gap, high chemical stability, good transparency in UV region [2]. Unfortunately, the high purity silica powder is very high in cost thus rice husks (RH) have been acquired in order to substitute the silica source as it is believed to contain 90 % of silica content in the WRHA to lower the cost of industrial production as rice husks can be easily obtained in most countries around Asia [3]. In this research, solid state method is used to prepare the Zn_2SiO_4 samples as it is simpler, energy and time consuming for large productions compared to chemical methods such as sol-gel method, spray pyrolysis method, hydrothermal method and co-precipitation method that is expensive and need longer period of time to prepare the samples [4].

MATERIALS AND METHODS

Synthesis

Raw rice husks (RH) were cleaned using tap water to remove residue dirt that are possibly attached to the RH and distributed uniformly in alumina boat and leaved into the oven for 12 hours with temperature of 120 ˚C. RH were burned at 1000 °C for 2 hours to obtained white rice husk ash (WRHA) as silica-based material. The WRHA were then grounded and sieve to 45 µm fine powders. Zn_2SiO_4 glass were prepared using conventional melt and quench technique with composition of ($ZnO_{0.60}$ – $WRHA_{0.40}$). The synthesis of glass system includes mixing zinc oxide (ZnO) nanopowders (US Research Nanomaterials, Inc., United State of America, 99+%, 10-30 nm ZnO) together with WRHA as the silica source and milled for 24 hours to ensure the powders are homogenous. The mixtures were melted for 3 hours with temperature 1450 ˚C and immediately quenched into a basin of water to form glass frits as it is formed due to rapid cooling process. The glass frits were crushed by ball milling process for 24 hours with 80-90 rpm and sieved again to 45 μm.

Characterization

The chemical composition of WRHA was confirmed using EDXRF diffractometer (EDX-7000). XRD is necessary to confirm amorphous glass nature phase between all different compositions recorded by Phillips X'Pert High Pro PANanalytical Diffractometer (XRD-6000). The data measured over 2θ range between 20°- 80° were analyzed using X'Pert Highscore Plus software and plotted using Origin Pro 8 software. Surface morphologies and grain structures of pellet samples which have been coated with a thin layer of gold (Au) were observed using FESEM (Nova NanoSEM 30 Series) under 50 000x of magnification.

RESULTS AND DISCUSSION

X-Ray Fluorescence Analysis

Table 1. Chemical composition of white rice husk ash (WRHA)

Elements	**Percentage (%)**
SiO_2	90.926
K_2O	3.718
Al_2O_3	3.491
Other oxides	1.865
Total	**100.000**

Chemical composition of WRHA was determined using EDXRF as shown in Table 1. From the table, it confirmed that WRHA contains a large amount of SiO_2 and other small percentages of K_2O and Al_2O_3. Other oxides such as P_2O_5, CaO, Fe_2O_3 and SO_3, MnO, ZnO, CuO, Cr_2O_3, TiO_2, NiO, Ag_2O, GeO_2, SrO and Rb_2O are also included as minority elements in WRHA. Thus, from this result, WRHA is proved be a good substituent to replace conventional high purity SiO_2 as according to previous researches [5].

CONCLUSIONS

In this study, the structural properties of the ($ZnO_{0.60}$ – $WRHA_{0.40}$) glass sample can be determined by XRF, XRD and FESEM analysis. XRF analysis shows that the SiO_2 content in the WRHA reached about 90 % which proved that WRHA is a good substituent to replace the conventional high purity silica to produce Zn_2SiO_4 glasses. The ($ZnO_{0.60}$ – $WRHA_{0.40}$) glass sample was observed to be amorphous nature phase through XRD analysis. FESEM confirmed the XRD results by showing the glassy surface of the sample which indicates the glass sample. For further study, the Uv-Vis-NIR and Photoluminescence spectroscopy should be done to study the optical properties of the samples.

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