CHAPTER 1 INTRODUCTION

1.1 Introduction

Radiation which are most important in nuclear reactor shielding are neutrons and gamma-rays originating within the core and the secondary gamma-rays produced by neutron interactions with materials external to the reactor core, for example, reflector, pressure vessel and shield, etc. Concrete is the most commonly used shield material as it is inexpensive and adaptable for any construction design. There are however many drawbacks associated with the usage of concrete, such as considerable variability in its composition and water content. This variation results in uncertainty in calculations for shield design predictions of the radiation distribution and attenuation in the shield. A large water contents leads to disadvantages of decreasing both density and structural strength of concrete, and the water is lost when concrete becomes hot by absorption of energy from radiation. Some special concretes of higher density than normal have been designed, consisting of element like barium and iron in addition to light elements. Another drawback is that concretes are opaque to visible light and thus it is difficult to see through the concrete-based shield. Therefore, it is an important task to develop better radiation shielding materials in term of size requirements and transparency to visible light [1]. Glass materials are one of the possible alternatives to concrete because they can be transparent to visible light and their properties can be modified by composition and preparation techniques. In nuclear industries, borosilicate glass is one of important glasses because it is mainly used as a medium for immobilizing the radioactive ions present in the waste generated from nuclear reactors and come from boron oxide and silica [2-4].

In Thailand, rice husk is one of the major agricultural wastes. The large proportion of it has been recycled as a raw material for Portland cement and another application e.g. refractory, insulator, waterproofing chemicals etc [5]. Nevertheless, the usage in these applications has low value in economics. Therefore, it is necessary to search for a new option for the usage of the rice husk ash. When the rice husk ash was burnt, it has a high silica content and low transition oxide contamination. Therefore, the burnt rice husk ash can be a substitution for silica source in the process to fabricate a borosilicate glass for gamma-rays shielding.

Barium is a good candidate for development of Ba-based radiation shielding glass owing to strong absorption of X-rays, gamma-rays and non-toxicity compared with lead and bismuth. In literature, many constituents of radiation shielding glasses e.g. lead-silicate, lead borate, bismuth borate, bismuth lead borate glass system [1, 6-8] have been reported, but report on barium-based glass is lacking. In the case of flyash, some literature has been published for barium-borate-flyash glass system as radiation shielding materials from thermal power plant flyash [9]. Unfortunately, flyash from power plant has a lot of transition oxide (such as Fe_2O_3) contaminations, which producing opaque property or high intensity of color in glass making the glass not suitable in practical usages. Until now, there is no report on the study of glasses production from rice husk ash in borosilicate glass as shielding materials.

The purposes of the present work are to prepare a xBaO-B_2O_3-RHA (rice husk ash) glass system and determine some shielding properties at 662 keV photon energy etc. mass attenuation, half-value layer (HVL), mean free path (MFP)

1.2 Motivation

Due to rising oil prices in all over the world, in the future Thailand needs to consider nuclear power as a source of energy. Moreover, there is increasing use of radioactive isotopes and accelerators in different fields. Therefore, it is very important to study how much protection the public can get while they are in nuclear power plant. Building and glasses are two main points have to be considered. In Thailand, rice husk is one of the major agricultural wastes and when the rice husk ash was burnt, it has a high silica content and low transition oxide contamination. Therefore, the burnt rice husk ash can is a substitution for silica source in the process to fabricate a borosilicate glass for gamma-rays shielding.

1.3 Objectives

1.3.1 To prepare a glass system of formula BaO:B_2O_3:RHA
1.3.2 To investigate the radiation shielding properties of BaO:B_2O_3:RHA glass system at 662 keV.
1.3.3 To investigate the physical and optical properties of BaO:B_2O_3:RHA glass system.

1.4 Thesis Significance

This research has led husk bake at various temperatures to determine the amount of silicon and applied in the synthesis of glass used for shielding radiation, which was to be the synthesis of chemicals, which constitute a value-added.

1.5 Literature Reviews

Singh N. et al. [10] studied the PbO-BaO-B_2O_3 glass system in terms of molar mass, mass attenuation coefficient and half value layer parameters by using gamma-ray at 511 keV, 662 keV and 1274 keV photon energies. Gamma-ray attenuation coefficients of the prepared glass samples have been compared with tabulations based upon the results of XCOM. Good agreement has been observed between experimental and theoretical values. The results have uncertainty less than 3%. Radiation shielding properties of the glass system has been compared with some standard radiation shielding concretes.

Singh N. et al. [11] measured the gamma-ray mass attenuation coefficients in experimentally and calculated theoretically for PbO–B_2O_3 and Bi_2O_3–PbO–B_2O_3 glass systems using narrow beam transmission method. These values have been used to calculate half value layer (HVL) parameter. These parameters have also been calculated theoretically for some standard radiation shielding concretes at same energies. Effect of replacing lead by bismuth has been analyzed in terms of density, molar volume and mass attenuation coefficient.

Singh K. et al. [12] reported the mass attenuation coefficients of glasses in the system $xBi_2O_3 : (1-x)B_2O_3$ (x=0.30, 0.35, 0.40, 0.45 and 0.55) at 356, 662, 1173 and 1332 keV photon energies using a narrow beam transmission method. Appreciable variations were observed in these coefficients due to changes in the chemical composition of glasses. These coefficients were then used to determine effective atomic numbers of glass samples, which were found to be constant with bismuth concentration and energy.

Singh K.J. et al. [13] determined the gamma-ray attenuation coefficients using a narrow beam transmission method for the $xPbO(1-x)SiO_2$ (x = 0.45–0.70) glass system at 662, 1173 and 1332 keV photon energies. These values have also been obtained theoretically using the 'mixture rule' and the 'XCOM' computer software. The results have been used to calculate half value layer parameters. Gamma-ray shielding properties of PbO–SiO_2 glass samples have been compared with standard radiation shielding concretes. The molar volume, FTIR and acoustic investigations have been used to study the structural properties of the prepared glass system.

Singh H. et al. [14] measured the gamma-ray mass-attenuation coefficient, the photon mean free path (MFP), the effective atomic number and the effective electron density for $xZnO \cdot 2xPbO \cdot (1-3x)B_2O_3$ (x=0.1–0.26) glasses at photon energies 511, 662, 1173 and 1332 keV and compared with theoretical data. The specific volume of the glasses has been derived from density measurements and studied as a function of composition. It is pointed out that these glasses have potential applications in radiation shielding.

Kaewkhao J. et al. [15] reported the mass attenuation coefficients, total interaction cross-sections, effective atomic numbers, effective electron densities and photon mean free paths of the Cu/Zn alloy on the basis of the mixture rule at 356, 511, 662, 835 and 1275 keV gamma-rays using narrow beam transmission method. It was observed that the mixture rule is a suitable method for determination of these parameters. The effective atomic numbers and effective electron densities tend to be almost constant as a function of energy. There is good agreement between experiment and theory, calculated by WinXCom.

Gerward L. et al. [16] reengineering version of XCOM, the well-known program for calculating X-ray and gamma-ray attenuation coefficients and interaction cross sections, has been developed. The new program run in windows, called WinXCom, has an improved user interface.

Singh S. et al. [9] measured the attenuation coefficients of barium–borate–flyash glasses for γ-ray photon energies of 356, 662, 1173 and 1332 keV using narrow beam transmission geometry. The photon beam was highly collimated and overall scatter acceptance angle was less than 3°. The results have an uncertainty of less than 3%. These coefficients were then used to obtain the values of mean free path (mfp), effective atomic number and electron density. Good agreements have been observed between experimental and theoretical values of these parameters. From the studies of the obtained results it is reported here that from the shielding point of view the barium–borate–flyash glasses are better shields to γ-radiations in comparison to the standard radiation shielding concretes and also to the ordinary barium–borate glasses.