Recycle Waste Glass for Thermal Insulator

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ABSTRACT

Series of ceramics from recycle waste glass and mica powder have successfully been made and their physical properties of these glasses which include density, bulk modulus, volume expansion and compressive strength have been determined. Comparison of their physical specification to the conventional insulators has also been made. The results show that these ceramics exhibit reasonable mechanical, thermal and physical properties to be a potential thermal insulators.

Keywords : Ceramics, mica, thermal conductivity

INTRODUCTION

Thousands tones of glass are discarded daily throughout the world, mostly in the form of non-returnable bottle and containers. A growing interest in conservation of resources and ecological preservation has led to an increase in the recovery of solid waste including glass. The need for recycling waste glass (cullet) is a way of saving not only raw materials but also energy (Norman 1980). It has been reported that for every 1 % of recycle waste glass been used as starting batch, it would save 0.5% of the combustion energy. But the collection of cullet in some countries, by any mean, is far from successful. In Malaysia, for example, some local glass manufacture has to import cullet only to fulfill the demand required by their factory. This is shown in Table 1. From Table 1, it can clearly be seen that the company has to import some of the cullet from neighboring countries with the total amount of 439.696 kg which is about 439.696 ton/month. It is therefore very imperative to seek for new product that is made based on recycle waste glass.

It has been reported earlier that when the recycle waste glass powder is mixed with mica powder and sintered at temperature about 800ºC, ceramics with different physical properties were produced (Havac 2002, Pask 2004). By controlling the mica content, it is always possible to change the physical and mechanical properties in such away that the ceramics with required properties can be produced. In this paper, some physical and mechanical properties that would give some indications of this ceramics to be insulators will be presented.

Table 1. The average collection of cullet for local glass manufacture, 2001 (source, Malaya Glass Sdn Bhd).

Source	Amount (kg)
Bottling Plant	825166
Thailand	263004
Singapore	91434
Locals	85258

METHODS

The glass powder used for the present investigation were prepared from recycle cullet supplied from local glass container manufacturer. The cullet was firstly ground into a relatively fine powder with mean grain size about 165μ m and 215μ m. Analysis using EDAX (Energy Dispersive of x-ray analysis) showed that the recycle waste glass powder consisted of composition as shown in Table 2. Meanwhile, the mica powder used in this investigation were of phlogopite type and were obtained from the local supplier and the content is shown as in Table 2.

A proportional amount of glass powder and mica are then well mixed to form a homogeneous mixture. A suitable amount of water was added as wetting agent as proposed by Reed [Reed, J.S. 1988]. This mixture was then poured into a mould before being dried in an oven at 60ºC for 24 hours. The sample were then sintered in an electrical furnace at 850ºC. The thermal conductivity has been determined using Lee's Disc Method which is commonly used for most poor conductor.

Table 3 shows the composition of cullet and mica that has been used in this experiment.

RESULTS AND DISCUSSION

As can be seen from Table 2, a wide range of ceramic may be obtained. However, composition with more than 50% of mica exhibits a distribution of crack and may not suitable for further investigation. On the other hand, ceramic with higher content of cullet exhibits a distribution of hole on the surface. For a mount more than 50 wt% the mixture will be very saturated and not homogenous.

Table 4 shows the thermal conductivity of ceramic. From Table 4 it can be seen that the thermal conductivity in the range of (0.45 – 0.675) $Wm^{-} K^{-1}$ may be achieved.

It can also be said that the value is decreasing with the increasing of mica content. Meanwhile, Table 5 shows the thermal conductivity of some commercial materials available in the market place. For comparison, the value of modulus of elasticity of cullet-mica ceramic and other material was also inserted (Noh 1988). From Table 5, it can be said that the thermal conductivity of these ceramic is much lower than that is available in the market. The modulus of elasticity of these materials is also comparable to the commercial materials.

Table 6 shows some specifications of the physical properties of cullet-mica ceramic which had been presented elsewhere (Brown & Mackenzie 1992, Charles 2008). It should be noted here that the properties are dependence on the composition of the mica content. It means that the manufacturer can tailor the formation of the ceramic according to the requirement (Rawson 1990). All the data shown in Table 5 and Table 6, the results might reflect that the degree of porosity of the sample become slightly higher when the mica content is increased and would suggest that this ceramic can be very potential as thermal insulators especially for building materials and medium temperature range furnaces.

Table 2. EDAX analysis on cullet and mica powder (wt%).

Components	Cullet (wt%)	Mica (wt%)
Si	35.95	24.20
O	43.07	42.71
Mg	0.23	0.69
Al	1.61	21.69
Fe	0.10	1.89
Na	10.88	~
Ca	6.16	~
K	~	8.26
F	~	0.11
Ba	~	0.45

Table 3. Composition of cullet and mica (wt%).

Sample no.	Cullet (wt%)	Mica (wt%)
S1	90	10
S2	80	20
S3	70	30
S4	60	40
S5	50	50

Table 4. Thermal conductivity of some ceramics composition.

Mica content (%)	Thermal conductivity, ($Wm^{-1}K^{-1}$)
10	0.675
20	0.556
30	0.512
40	0.479
50	0.450

Table 5. Comparison of the thermal conductivity of some commercial ceramics.

Ceramic type	Modulus of elasticity	Thermal conductivity ($Wm^{-1} K^{-1}$)	Application
Cullet-mica	(27-47) x 10^3	0.4 – 0.7	Thermal Insulators
Magnesite (brick)	170 x 10^3	3.8	Steel Melting Furnace
Fireclay brick	97 x 10^3	1.5	Heaters Lining
Porcelain	69 x 10^3	1.9	As an alternative in the aesthetic restoration of the anterior teeth.

Table 6. Some specifications of cullet-mica ceramic (Brown & Mackenzie 1992, Rawson 1990).

Properties	Physical values
Bulk Modulus ($kgm^{-1} s^{-2}$)	(1 – 10) x 10^{10}
Volume expansion (%)	(-25 – 7)
Compressive Strength (Mpa)	> 120
Bulk Density (gcm^{-3})	(1.5 – 2.4)
Max. operating Temperature (C)	600

In a transparent material such as glass, any measurement of conductivity become complicated by the fact that glass also conducts heat internally by radiation. Hence published figures for glass thermal conductivity show considerable disagreement and because of this uncertainty, thermal conductivity in glass is not used extensively as a design parameter (Koller 2010). Therefore it is suggested that a study should be carried out in order to overcome this uncertainty.

CONCLUSION

The present study has shown that some samples exhibit a unique composition in which the properties is found to be superior than some of the conventional insulating materials. This would suggest that the glass-mica ceramic materials are potential structural elements for thermal insulating application. What's more, this mixure seems to be environmental friendly.

REFERENCES

Brown JWM & Mackenzie KJD. 1992. Process Design for the Production of Ceramic-like Body from Recycled Glass. *J.Mat. Sc*. **17**:2164-70.

Charles, Harper A. 2008. *Handbook of Ceramics, Glasses, and Diamonds*. McGraw-Hill.

Havac J. 2002. *The Technology of Glass and Ceramic: an Introduction*. Elseiver Sc. Pub. Co. New York.

Koller, A. *On Science, Art, Technology, A Resource of Glass, the Corning Museum of Glass*. http://w.w.w. Cmog.org/Education/ edprglop.html. [12 December 2010].

Noh MZ. 1988. *Effect on Composition, Sintering and Graind Size on Cullet-mica Ceramic System.* Unpublished Msc Thesis, Universiti Teknologi Malaysia.

Norman MDL. 1980. Glass Recycling. *J.Mater. Sci* **15**: 2497-507.

Pask JA. 2004. *Ceramic Material Processing Character*. China:Science Press..

Rawson H. 1990. *Properties and Application of Glass*. Elseiver: Amsterdam

Reed JS. 1988. *Introduction to Principles of Ceramic Processing*. New York; John Wiley & Son.