Asian Journal of Chemistry; Vol. 23, No. 8 (2011), 3384-3386

ASIAN JOURNAL OF CHEMISTRY

www.asianjournalofchemistry.co.in

Preparation and Characterization of Foam Glass Based Waste

N. STITI[1,*], A. AYADI[1], Y. LERABI[1], F. BENHAOUA[1], R. BENZERGA[2] and L. LEGENDRE[2]

[1]Department of Material Engineering, Faculty of Science and Engineering, Material Mineral Composite Laboratory, Boumerdes University, 35000 Boumerdes, Algeria
[2]Institut d'Electronique et de Telecommunication de Rennes.UMR CNRS 6164, France

*Corresponding author: Tel/Fax: +213 24 816408, E-mail: lastiti@yahoo.fr

(*Received*: 26 July 2010; *Accepted*: 15 April 2011) AJC-9807

The porous glass 'foam glass' is considered as the new glass products fulfill certain requirements in the building industry in particular (thermal and acoustic insulation). The production of foam glass based waste glass plays an important role in environmental protection and also gains in energy. As part of present work, we seek to improve the properties of glass to obtain a building material lighter with excellent insulation properties. The properties of foam glass depend on the porosity and morphology. The present work devoted to analyze the microstructure of the glass produced by scanning electron microscopy and optical microscopy to be more precise on the size and shape of pores constitute this material.

Key Words: Glass, Recycling, Porous, Composite, Insulation.

INTRODUCTION

Since the 1970s, all industrialized countries pursue a policy of saving energy, causing a considerable development of the thermal insulation industry[1].

Modern insulators are in the majority porous light weight materials, in which heat transfer occurs by both conduction and radiation. These materials are porous with solid matrix containing closed or open cells, containing air or other gas used to expand the initial material. Among cellular insulators, most common are light weight cellular concrete and cellular glass[1]. The cellular glass is much better known by its trade name foam glass. This type of glass has a cell structure rigorously closed with cell diameter relatively large (*ca.* 0.1 mm)[2]. Its density is between 120 Kg/m^3 and 165 Kg/m^3 depending on the product, thermal conductivity is taken as 0.05 W/mK, the coefficient of thermal expansion is 9×10^{-6} K^{-1}, the compressive strength is between 0.7 and 1.6 N/mm^2. It is incombustible (rated MO), unalterable and incorruptible. Finally, it does not attract insects or rodents[3].

EXPERIMENTAL

Preparation of foam glass: The cullet glass recovered in unit of glass production (Somiverre) of Boumerdes (Algeria), served as raw material for the preparation of foam glass, its chemical composition is as follows: 69 % SiO_2, 13 % Na_2O, 5 % CaO, 4 % Al_2O_3, 3 % K_2O, 3 % MgO, 2 % BaO, 1 % B_2O_3. The foam glass (Fig. 1) is obtained by sintering. The manufacturing process used is pressing the mixture of glass powder (99 %) and foaming agent (1 % $CaCO_3$) with humidity and pressure compaction optimized to 8 % and 400 bars.

Fig. 1. Sample of manufactured foam glass

The thermal regime selected, is to increase the temperature linearly at a rate of 10 °C/min up to 850 °C. The temperature is sets for 10 min and finally the simple is left to cool slowly inside the oven, to allow the material to develop a good mechanical strength.

RESULTS AND DISCUSSION

Porosity measurements: The porosity is defined as the ratio of the volume of voids (v_v) in total volume (v_t) of the body considered. The volume of solid (v_s) is given by $v_s = v_t - v_v$. It is therefore sufficient to measure two of these three parameters to calculate the porosity[4]. By this method, a value of 85.11 % is obtained as shown in Table-1.

TABLE-1
CHARACTERISTICS OF MANUFACTURED FOAM GLASS

Melting temperature (ºC)	1000
Porosity (%)	85.110
Water absorption (%)	73.176
Density (g/cm^3)	0.831
Thermal conductivity (W/m ºC)	0.031
Specific heat (KJ/m ºC)	375.700
Coefficient of sound insulation (dB)	15.000

Analysis by scanning electron microscopy and optical microscope: Using the scanning electron microscope and the optical microscope type Leica DMLM we have made interesting micrographs (Figs. 2 and 3) from witch we obtain an estimate of the size of pores.

The SEM observation allowed to see clearly and to demonstrate that the foam glass has an inhomogeneous structure. This is probably due to the foaming process. With this observation mean we got to get more accurate estimates of the elaborated foam glass pores sizes and we distinguish three different porosities in the samples of foam glass.

Foam glass has an inhomogeneous type of pore volume distribution. This is especially marked as shown in Fig. 2(c) and Fig. 3(c) with a large pore size. The large pores are surrounded by medium and small pores. This micrograph provides an estimate of the average diameter of small pores found on the skeleton between two big pores. As illustrated, there are two sizes of pores:

Smaller: D = 100 µm

The biggest: D = 300 µm

On the other hand, the samples of foam glass are characterized by homogeneous regions; the average diameter of pores is about 0.8 mm [Figs. 2(a) and 3(b)].

In examining the photomicrograph of other region of the sample (Fig. 2(b)) one can see the small pores which are located on the skeletons and depths of pores whose average diameter is 2 mm.

Compressive strength measurements: The compressive strength of foam glass is between 0.7 and 1.6 N/mm^2, as we can see in Table-2 this property as other properties of foam glass are largely dependent on the porosity and morphology and also on apparent density.

TABLE-2
INCREASING OF COMPRESSIVE STRENGTH WITH THE APPARENT DENSITY

Apparent density (g/cm^3)	Compressive strength (MPA)
1,05	17.50
0.65	15.09
0.45	13.57
0.25	11.25

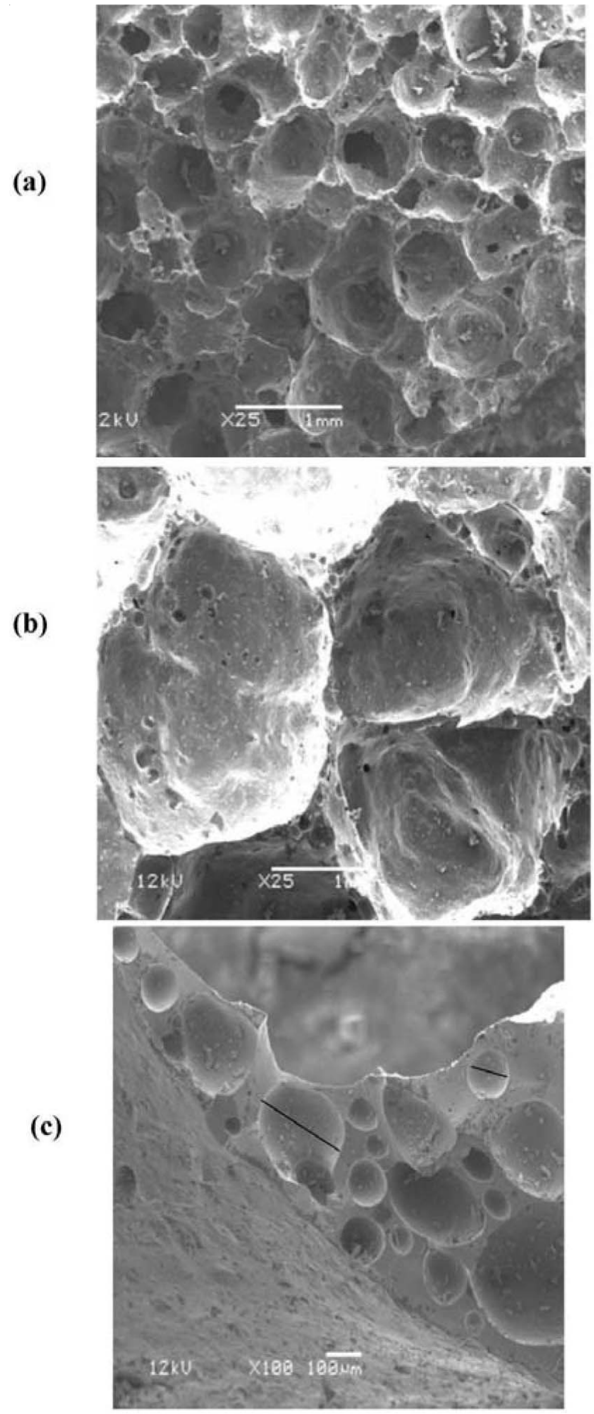

Fig. 2. SEM micrographs of the simple of foam glass

Acoustic and thermal insulation of foam glass: To be effective, the foam must have open cell, is to say, communicating with each other so as to provide an absorbent surface as large as possible.

An insulator is a body of low thermal conductivity. The thermal conductivity of a material expresses the power transmitted by a layer of a meter thick on a square meter, the temperature difference between the two sides of being a degree. This property is an intrinsic to material.

A good insulation is still air (= 0.024 W/m ºC). This property is used in all insulation materials that trap air in fibbers or in the pores. These pores should be neither too small (their

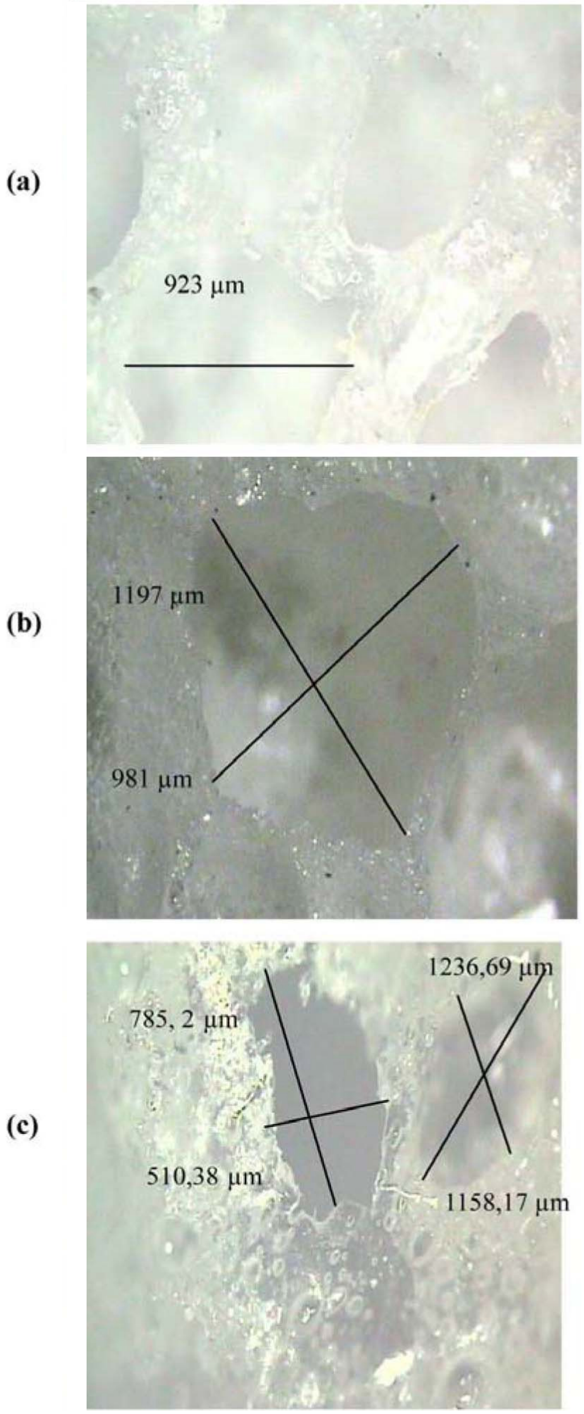

Fig. 3. Optical microscopy micrographs of the simple of foam glass

effect would be negligible) nor too large (the air included would be animated the convective movements which increase the transfer of heat)[5].

As shown in Table-1, the coefficient of thermal conductivity of glass produced is 0.031 W/m ºC. This value is much lower than other insulation.

The acoustic porous materials are the most common method used to control noise or absorb sound. Their efficiencies are governed by the dissipative and heat effects that take place between the fluid and solid phases of these materials.

The foams are characterized by a high absorption at high frequencies and a much lower absorption at low frequencies. The absorption coefficient increases with the porosity of the material; this factor is also related to the thickness of the material.

Conclusion

Foam glass is especially known for these good thermal and acoustic insulation properties. This type of glass is often produced from waste glass[6].

The elaborated material is based on 99 % of waste glass and 1 % limestone as foaming agent, which are only industrial waste (cullet) and a natural rock, abundant and cheap in Algeria (limestone)[7].

The waste recycling has a very large extent. It is not limited to energy saving in the manufacture of building materials on an industrial scale and it contributes significantly to protecting the environment.

The foam glass is interesting for these applications in building insulation. This glass is an insulator, ecologically[8]; it has no toxic emissions during use.

The foam glass obtained in the form of plaques found various applications in the field of construction such as ceiling insulation, chimneys, roofs and surface-ripened, it can also serve as a float (as an indicator of the level of a liquid).

The phenomena occurring in porous media depend, in general, a number of properties including: storage properties of fluids (either absorbed on the solid form or filling the pores), the transfer properties (mass, momentum, energy) and finally the mechanical properties[9].

As with all multiphase heterogeneous systems, these properties are obviously depend on the matrix morphology and phenomena that develop and interact in different phases.

The porous structure of foam glass is the key factor that enables the glass to absorb thermal and acoustic waves. The SEM and the optical microscopy showed that the manufactured foam glass is characterized by a large porosity in the majority. The existence of two types of pores of different sizes makes the acoustic behaviour of a material more complex.

The sound absorption is due to viscous friction between fluid and solid skeleton, because they have different speeds. This damping exists only if the sound wave can penetrate the porous network and it is even stronger than the surface of contact between fluid and solid is large. The sound absorption is favoured when the porosity is open.

REFERENCES

1. C. Langlais and S. Klarsfeld, Engineering Techniques, Construction Treaty, Thermal Insulation at Room Temperature (Physical basis).
2. J. Danckaert, Industrial Thermal Insulation, Technical Publishing and Documentation, Paris (1981).
3. G. Karsenty, The Production of Building (The Second Work), Eyrolles (2001).
4. T. Bourbie, O. Coussy and B. Zinszner, Acoustics of Porous Media, Technip (1986).
5. S. Belakhowsky, Heat Loss and Home Insulation, Technical & Extension, Paris (1978).
6. F. Méar, P. Yot, R. Viennois and M. Ribes, *Ceramics Int.*, **33**, 543 (2007).
7. A. Ayadi, M.Palou and A. Iratni, *Verre*, **10**, 68 (2004).
8. V.E. Manevich and K.Yu. Subbotin, *Glass Ceramics*, **65**, 154 (2008).
9. S. Bories and M. Prat, Engineering Techniques, Power Engineering Treaty, Transfer of Heat in Porous Media.