ELABORATION AND CHARACTERIZATION OF AN INSULATION MATERIAL BASED WASTE GLASS

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Abstract

The policy of energy conservation and construction of acoustic comfort is the basis of search for new compounds to improve the performance of materials currently on the market.

It is within this context that our work to obtain a building material much lighter with properties improved thermal and acoustic insulation from waste glass and calcium carbonate as a foaming agent.

The manufacture of foam glass from waste glass recycling is a way that fits with the objective of environmental protection and maximum recycling of household waste. The energy savings achieved through the use of cullet result in a decrease in air pollution, especially carbon dioxide (CO_2), and reduced the price of glass.

The results of the microstructure clearly demonstrate that the addition of $CaCO_3$ increases the porosity of the foam glass which gives a low thermal conductivity and increases its thermal insulation capacity (λ= 0.026 W/Nm^2), which promotes its use in the building industry.

Keywords: cullet, environment, energy, recycling; thermal insulation.

1- INTRODUCTION

Protection of the environment becomes increasingly a collective concern. The waste issue is daily and affects every human being both professional and family. As a consumer, producer, user of garbage collection and sorting of recyclable waste, citizen or taxpayer, everyone can and must play a better waste management.

Insulating materials are modern in their most lightweight porous materials, in which heat transfer occurs by both conduction and radiation [1].

These are the materials consolidated porous solid matrix containing closed or open cells, containing air or other gas used to expand the initial material. Among the cellular insulation of mineral origin, are the most popular lightweight cellular concrete and foam glass [2-3]. The glass also called cellular foam glass is much better known trade name is Foam glass [4].

This type of glass has a cellular structure rigorously closed cells of relatively large diameter (about 0.1mm) [5-6].

The foam glass differs from the other glass materials by its specific structure which consists of a skeleton and glass inclusions of gas within the pores predominantly non-communicating. This gas phase determines the specific properties of this material and especially its thermal resistance. The main raw material for the development of foam glass cullet. In this study, we seek to improve the porosity of the foam glass to obtain a lighter construction material with excellent insulation properties. To do this, we substituted a part of cullet by the addition of 1% $CaCO_3$ from the burden of foam glass.

2- MATERIAL AND METHOD

The foam glass is obtained by sintering, the manufacturing process used is the pressing of the powder mixture of waste hollow glass crushed glass to 100 microns (99%) and the foaming agent (1% $CaCO_3$) with a moisture content of 13% and a compaction pressure of 400 bar.

For the choice of optimum temperature, the duration was fixed plate (20 minutes) and varied the heating temperature of 700 ℃ to 900 ℃, with an interval of 50 ℃ (figure1.).

The thermal regime chosen is to increase the temperature linearly at a rate of 6.5 ℃ / min to 850 ℃., the temperature for a fixed level of 10 minutes, finally allowed to cool inside the oven (very slow cooling) to allow the material to acquire good mechanical strength. Figure 2 shows samples of the foam glass elaborated by wet process.

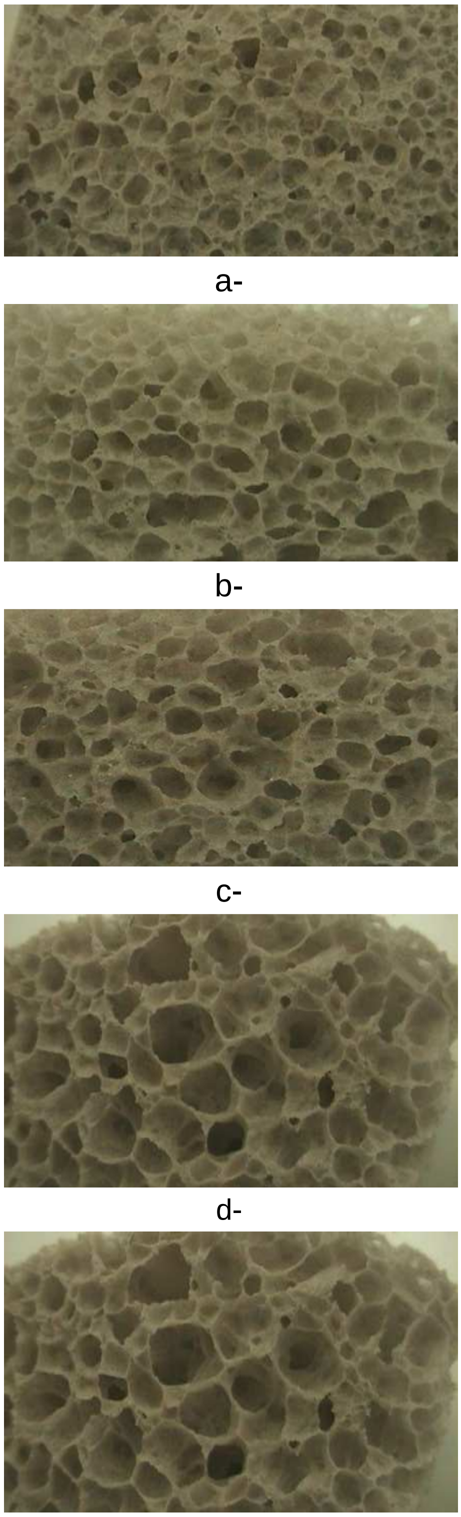

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Figure 1: Photos of foam glass produced at different temperatures a- 7OO ℃, b-750 ℃, c- 800 ℃, d- 850 ℃, e- 900 ℃

Figure 2: foam glass obtained by wet process

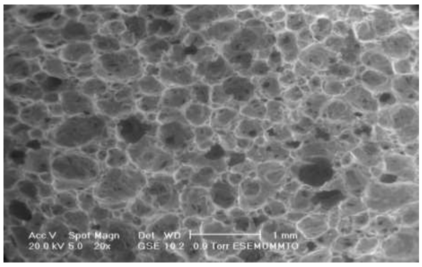
3- RESULTS AND DISCUSSION

3.1- The Morphology of foam glass elaborated

The morphology of the foam glass samples is carried on fragments of about 0.5 cm^2 surface by scanning electron microscope SEM Philips ESEM XL type 30, the results are illustrated in Figure 3.

According to the results of the microstructure of foam glass, we see that:

- Increasing the temperature influences the pore size;
- Morphology of foam glass show the presence of interconnected pores, it highlights a dual distribution much more heterogeneous, with small pores that are inserted between the large pores (joints of pores), whose size varies only slightly within the same distribution;
- The form of small pores is more uniform, spherical form, by the large pores are against any form.



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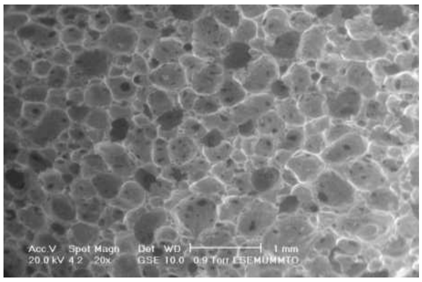

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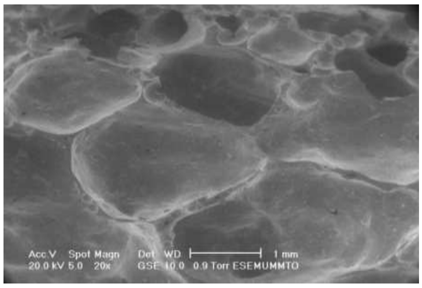

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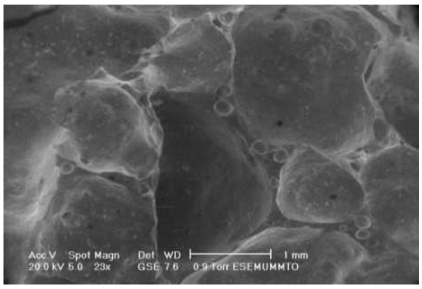

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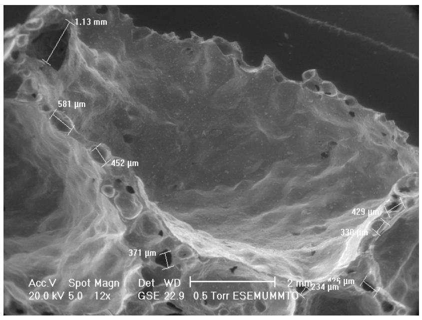

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Figure 3: Micrograph (SEM) of foam glass, a-7OO ℃, b-750 ℃, c- 800 ℃, d- 850 ℃-, e- 900 ℃

3.2- Differential Thermal Analysis - Thermogravimetric (DTA-TGA)

The purpose of this study is to identify the range of foaming gas evolution and its influence on the material developed. This analysis was performed using a type apparatus NETZSCH STA 409PC. The analyzes were performed on the same operating conditions of sample preparation at a temperature of 850 ℃ with a heating rate of 6.5 ℃ / min.
According Thermograms of samples shows that:
- The release of carbon dioxide is more intense, it starts from 680 to 720℃.
- The first endothermic peak of each thermogram corresponds to the release of physically bound water, the mixing water.
- The second endothermic peak of each thermogram corresponds to the release of carbon dioxide.
- The first reduction of the mass is characterized by a high amplitude (20.3 and 22.5%), that due to the vaporization of physically bound water, water added during mixing, which is varied between 13 and 15% by weight.
- The second loss of mass is characterized by low amplitude, corresponds to the decomposition of carbonate species, these species have a high temperature emit carbon dioxide which allows our material to give a porous structure.
- The addition of water the mixture of powders allows to accelerate the carbonation of calcium and at the same time homogenizing the powder mixture. Thus $CaCO_3$ at high temperature involved in the release of carbon dioxide CO_2 and help to reduce the viscosity of the mixture, giving a larger volume in pores.

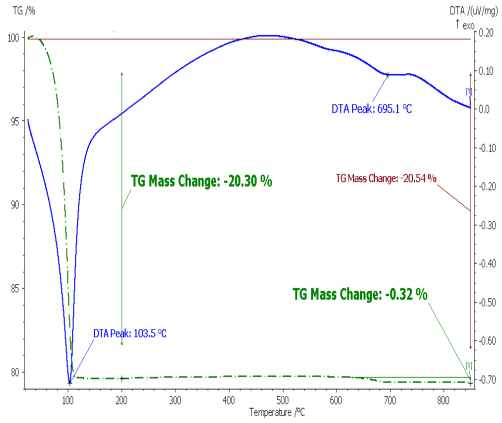

Figure 4: DTA-TGA Thermograms

3.3- Characterization of elaborate material

A certain number of physical and chemical characteristics of the elaborate product are gathered in table 1.

Table 1: *Characteristics of foam glass elaborate*

Caracteristics	Values
Density ρ (g/cm3)	0.5
Porosity (%)	85
Average density (g/cm^3)	0,45
Absorption of water (%)	10
Compressive strength (MPa)	6
Coefficient of heat insulation λ(W/m℃)	0.026
Coefficient of soundproofing R (dB)	15
Maximum temperature of use ℃	450
Thermal dilation coefficient α (℃-1)	93.10^{-7}

4- CONCLUSION

The foam glass is best known for the good properties of acoustic and thermal

insulation, it is interesting for these applications in building insulation. This glass is an environmentally insulation material, it has no toxic release during use.
The resulting product has excellent thermal properties, which favors its use in the construction industry. The decorative foam glass can widely use in the development of ceilings, chimneys, roofs, coating ripe halls, theaters, concert halls, studios, broadcasting and local sources to indoor sound annoying such as hospitals.
The manufacture of foam glass from waste glass recycling is a way that fits with the objective of environmental protection and maximum recycling of household waste. The energy savings achieved through the use of cullet result in a decrease in air pollution, especially carbon dioxide (CO_2), and reduced the price of glass.
The results of the microstructure clearly demonstrate that the addition of alkali silicates increases the porosity of the foam glass which gives a low thermal conductivity and increases its thermal insulation capacity (λ= 0.026 W/nm2).
The gravimetric and differential thermal analysis showed that $CaCO_3$ participates in the formation of the porous structure by the release of carbon dioxide, which favors their use as a foaming agent. The foaming interval (680 to 720 ℃) corresponds to the second endothermic effect.
Thermal insulation can both reduce your energy consumption for heating and / or air conditioning and increase your comfort. But that's not all: the insulation is also environmentally beneficial because, by reducing consumption, it helps preserve energy resources and reduce emissions of greenhouse gases. Thus, the thermal insulation is interesting in terms of environmental protection, comfort and savings.

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