



PHYSICAL CHEMISTRY 2021

15th International Conference
on Fundamental and Applied Aspects of
Physical Chemistry

Proceedings
Volume II

The Conference is dedicated to the

*30th Anniversary of the founding of the Society of Physical
Chemists of Serbia*

and

100th Anniversary of Bray-Liebhafsky reaction

**September 20-24, 2021
Belgrade, Serbia**

Title: Physical Chemistry 2021 (Proceedings) **ISBN** 978-86-82475-40-8

Volume II: ISBN 978-86-82475-39-2

Editors: Željko Čupić and Slobodan Anić

Published by: Society of Physical Chemists of Serbia, Studentski Trg 12-16, 11158, Belgrade, Serbia

Publisher: Society of Physical Chemists of Serbia

For Publisher: S. Anić, President of Society of Physical Chemists of Serbia

Printed by: "Jovan", <Printing and Publishing Company, 200 Copies

Number of pages: 6+388, Format A4, printing finished in December 2021

Text and Layout: "Jovan"

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CONTENT

<i>Volume II</i>	
<i>Organizer</i>	IV
<i>Comittes</i>	V
<i>Organic Physical Chemistry</i>	345
<i>Material Science</i>	367
<i>Macromolecular Physical Chemistry</i>	487
<i>Environmental Protection, Forensic Sciences, Geophysical Chemistry, Radiochemistry, Nuclear Chemistry</i>	519
<i>Phase Boundaries, Colloids, Liquid Crystals, Surface-Active Substances</i>	633
<i>Complex Compounds</i>	643
<i>General Physical Chemistry</i>	655
<i>Pharmaceutical Physical Chemistry</i>	669
<i>Food Physical Chemistry</i>	679
<i>Physico-Chemical Analysis</i>	703
<i>Index</i>	725



PHYSICAL CHEMISTRY 2021

*15th International Conference on
Fundamental and Applied Aspects of
Physical Chemistry*

Organized by

*The Society of Physical Chemists of
Serbia*

in co-operation with

Institute of Catalysis Bulgarian Academy of Sciences

and

*Borekov Institute of Catalysis Siberian Branch of
Russian Academy of Sciences*

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EFFECT OF SINTERING TEMPERATURE ON THE COMPRESSIVE STRENGTH AND MICROSTRUCTURE OF GLASS FOAM MADE FROM WASTE MATERIALS

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ABSTRACT

Glass foams were produced from a green beer bottle and sugar beet factory lime (SBFL) as the foaming agent. The sintering temperature was in the 750-900 °C range. Porosity and compressive strength were determined. Results showed that glass foam sintered at 750 °C has the best compressive strength and even distribution of pores throughout the volume of the sample. With the increase of temperature from 800 to 900 °C compressive strength was improved while porosity has slightly dropped. Pores with diameters greater than 1000 µm were formed due to pore agglomeration. Obtained glass foams have properties comparable to commercial ones.

INTRODUCTION

Glass foams are lightweight porous material used in sound and thermal insulation [1]. In the preparation of glass foam, the glass powder is mixed with a foaming agent. The mixture is then heated above the glass-softening temperature, where sintering of the glass powder and release of gases from the foaming agent occurred [2]. Gases from the foaming agent can be released by redox reactions or by thermal decomposition. In foaming by redox reaction, foaming is induced by carbon oxidation [3, 4]. Another way for gas release is the thermal decomposition of the foaming agent, most commonly CaCO₃, where CO₂ is formed, and CaO is incorporated into the molten glass mass and acts as a glass modifier, altering the viscosity of the molten glass [1, 5]. Recently, there is an increased interest in researches where CaCO₃ rich wastes are used as a foaming agent for glass foam production [6, 7]. In this research discarded green beer bottle is used as a glass matrix and SBFL is used as a foaming agent. SBFL is CaCO₃ rich waste generated during the purification of diffusion juice in a sugar factory. The possibility of obtaining foam glass with properties comparable to commercial ones, using only waste materials, was investigated [1].

METHODS

The green beer bottle was used as a glass raw material. It was milled into fine particles with TENCAN planetary mill at 400 rpm for 30 min. Obtained glass powder was sieved to obtain glass powder particles size under 50 µm. SBFL was used as a foaming agent. SBFL was dried in an oven at 110 °C, then crushed in an agate mortar and sieved to particles size under 50 µm. The chemical compositions of the glass and SBFL were determined using gravimetric and spectroscopic methods (AAS Analyst 300).

Glass powder (1 g) was mixed with 1% of SBFL in an agate mortar and then uniaxially pressed in a laboratory hydraulic press at 20 MPa with the addition of 5% H₂O as a binder. The obtained samples were 15 mm in diameter and 3 mm thick. Samples were heated at the selected temperature (750, 800, 850, and 900 °C) for 30 min using the heating rate of 10 °C min⁻¹ in an electric furnace (Carbolite CWF 13/13) and then cooled in the air.

The porosity of samples was calculated using equation (1)

$$\varepsilon = (1 - \rho_g / \rho_t) \times 100 \quad (1)$$

where ρ_g is geometrical density determined using an analytical balance and a caliper, and ρ_t is a true density determined by the pycnometer method with distilled water as medium fluid. The mechanical strength of the samples is determined by compression tests (KS model). Tests were performed on three samples.

The microstructure of the glass foam samples was examined using a scanning electron microscope (MIRA3 XM TESCAN).

RESULTS AND DISCUSSION

Table 1. shows the results of the chemical analysis of the green bottle glass.

Table 1. Chemical analysis of bottle glass

Oxide	SiO ₂	Al ₂ O ₃	CaO	MgO	Na ₂ O	Fe ₂ O ₃	MnO	Cr ₂ O ₃
mass %	71.9	2.46	10.2	2.10	12.7	0.42	0.01	0.11

The chemical composition of glass is typical for container soda-lime glasses. Chemical analysis of SBFL shows that it consists of 69.21% CaCO₃.

In figure 1 is shown the temperature effect on the compressive strength and porosity of glass foam. It can be seen that the highest porosity (94.81±0.64 %) and the lowest compressive strength (0.31±0.1 MPa) has sample sintered at 800 °C. With the temperature increase, the porosity drops, and the compressive strength is increased. The compressive strength of the sample sintered at 750 °C is the highest, and porosity is comparable to commercial glass foams (85-95%) [1].

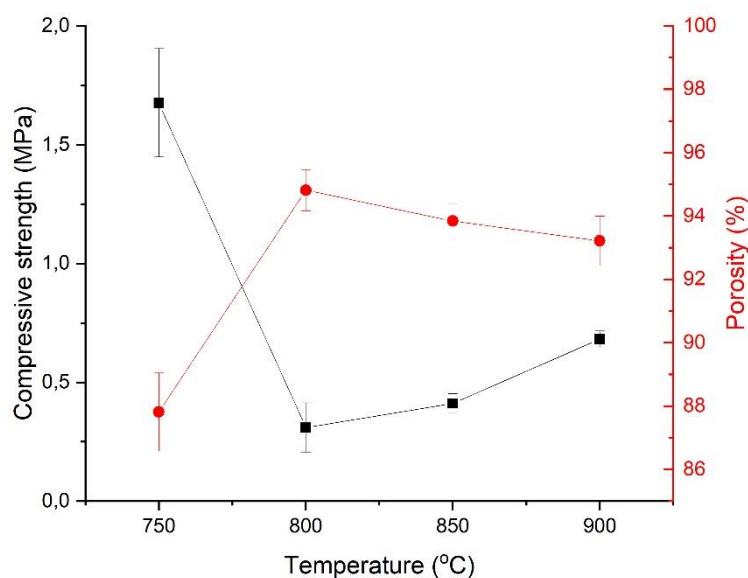


Figure 1. Temperature effect on the compressive strength and porosity of glass foams.

In figure 2 are shown SEM micrographs of obtained glass foams.

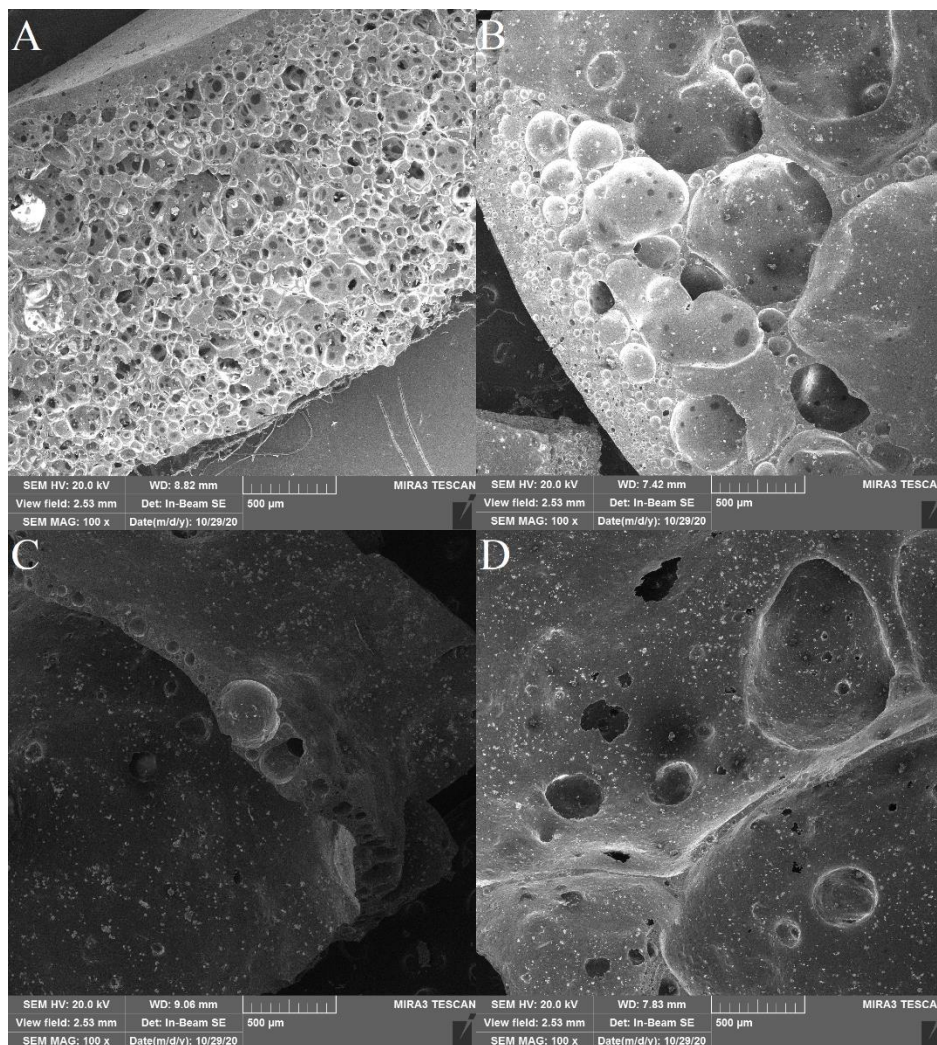


Figure 2. SEM Micrographs of glass foam sintered at A- 750 °C, B- 800 °C, C- 850 °C and D- 900 °C

Figure 2 shows that glass foam sintered at 750 °C forms pores with a diameter up to 200 μm . The sample has a more evenly pore size distribution throughout volume than samples sintered at higher temperatures. At higher temperatures pore agglomeration occurs that leads to the formation of pores with a diameter greater than 1000 μm . The compressive strength of glass foam is under the strong influence of uneven pore size.

CONCLUSION

Glass foam has been successfully prepared using only secondary raw materials. The best compressive strength and the evenest microstructure has glass foam sintered at 750 °C, with properties similar to commercial glass foam products. In temperature range from 800 to 900 °C the compressive strength increases, while porosity slightly drops.

Acknowledgement

This research was supported through the Ministry of Education and Science of the Republic of Serbia, grant contract No.: 451-03-9/2021-14/200135 and 451-03-9/2021-14/200023.

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