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The Study of Antibacterial Effect of the A_2O-B_2O_3 - CaO - P_2O_5 System

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Abstract The present paper studied the antibacterial effect of the $1.5Ag_2O$ 98.5% [47 B_2O_3 (53-x)CaO xP_2O_5] system for $0 \leq x \leq 10$, by the diffusion method in agar. The oxidic system has an inhibitive effect upon both studied strains of *Pseudomonas* and *Staphylococcus aureus*, bacterial growth being inhibited to a maximal diameter of 20 mm. *Staphylococcus aureus* was less sensitive to the action of the compounds, the highest inhibition diameter being of 15 mm.

Keywords: glass, silver, antibacterial efficacy

INTRODUCTION

Oxide glass based on B_2O_3 was thoroughly investigated (Baia *et al.*,2003 , Kamitsos *et al.*,1986) and it was proved that it consists of [BO_3] individual structural units or which build nets with six members denominated boroxol $B_3O_{4.5}$. The adding of oxidic components, denominated vitreous net modifiers, complicates its internal structure, giving birth to new structural units (Dimitriev *et al.*,2008) as well as physical properties.

From the biological point of view the glasses containing P_2O_5 and CaO are important due to their bioactivity. Thus, in the conditions of a real or a stimulated body fluids (SBF) and if there are certain relations between the components, on the surface of the materials a $Ca_{10}(PO_4)_6(OH)_2$ hidroxyapatite layer forms compatible with bone tissue (Hench,1998 , Saranti *et al.*, 2006).

The most useful are those that stimulate bone growth and after that resorb living the place for the formed bone tissue. A distinct category of oxidic glass is that in which materials containing Ag_2O are included. Their medical utility resides in that at the place of the implant infections appear that can be fought against with the Ag^+ ions (Bellatone *et al.*,2000) dissolved in the material from the organic inorganic contact surface.

In the present study we investigated the antibacterial effect of the $1.5Ag_2O$ 98.5% system (Simon *et al.*,2007) obtained through the method of undercooling melting method and processed to powder in the case of the Pseudomonas and *Staphylococcus aureus* strains through the diffusion method in agar for the purpose of their use in the treatment of the infections caused by these strains.

MATERIALS AND METHODS

Oxide glass belonging to the $1.5Ag_2O$ 98.5% [47 B_2O_3 (53-x)CaO xP_2O_5] vitreous system with $0 \leq x \leq 9$ have been obtained from Ag_2O,CaCO3, H_3BO_3, P2O5 of reagent grade purity. Mixtures were melted in air at 1200 °C, sintered corundum crucibles, and maintained 15 min. at this temperature.

Molted pieces were broken in a agate mortar and crushed into fine powder. Powders thus obtained were passed through the site with pore diameters of 75 μm to obtain material with controlled grain.

Antibacterial efficacy of the compounds investigated was tested on *Pseudomonas* and *Staphylococcus aureus* using the diffusion method in agar gel 2%. Agar poured into Petri dishes with a diameter of 12 cm, was sown with bacterial inoculums, prepared from 24-hour culture on agar, diluted in saline tube density of 1 McFarland scale. Immediately after sowing were charged 3.5 mm diameter wells, the compounds were assigned a concentration of 15% in quantity of 40 ml / well. Each compound was tested in duplicate. The diameters of inhibition zones were read after incubation for 24 hours at 37°C, being expressed in mm.

RESULTS AND DISCUSSION

In presence of the studied compounds the strain, the diameter of the inhibition area of the *Staphylococus aureus* strain grows linear (Fig. 1) once with the increase of the P_2O_5 content of the vitreous matrix. If it is admitted that the only component with antibacterial effect is silver than once with the modification of the $k=P_2O_5/CaO$ ratio in the B_2O_3-CaO-P_2O_5, matrix, the chemical durability of the sample changes dramatically. Thus, the average increase of the diameter of the inhibited area is $\Delta d =$ 6 mm, while the ratio $k \in [0 ; 0.23]$.

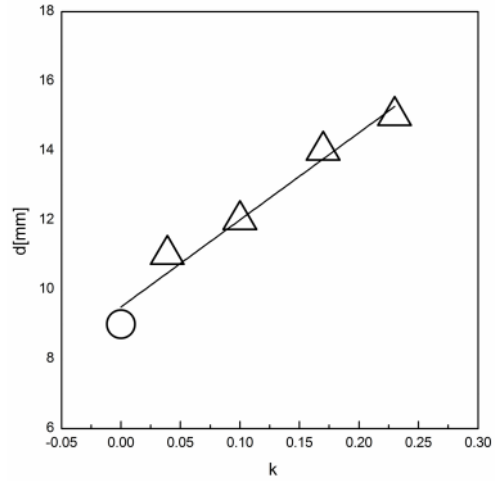

Fig. 1 The dependece of the inhibition diameter on the P_2O_5 concentration in the matrix in the case of the *Staphylococus aureus* strain.

Also, it can be deduced indirectly from the observation of evolution of the inhibition disk that once with the decrease of the CaO content (growth of k factor) the solvability of the samples increases together with P_2O_5 content in samples, being in agreement with data from the specialty literature (Ahmed *et al.*,2004 , Bengisu *et al.*,2008).

In the investigated compositional range the action of the $1.5Ag_2O$ 98.5% [$47B_2O_3$ (53-x) CaO xP_2O_5] compounds is more intense in the case of the Pseudomonas strain than in case of the precedent one (*S. aureus*) the diameter of the inhibition area being within the interval [9 ; 20] mm.

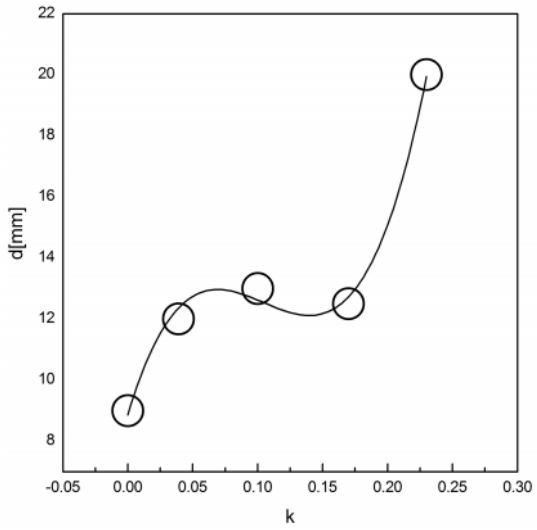

Fig. 2 The dependence of the inhibition diameter on the P_2O_5 concentration in glass matrix in the case of the *Pseudomonas* strain

In this case there also is a reliance of the area inhibited by the composition of the glass and the surface in contact with the nutritious area in which the studied strain was inseminated. When k = 0.25 the reliance achieves the maximum value d_{max}=20 mm, as it can be observed for $x \in [0.2;0.8]$ the graphic presents a landing around the value of the diameter of 12.5 mm and the process could have been considered saturated but for $x > 0.8$ structural modifications take place that decrease the chemical durability of the samples in the studied biological environment manifested by growth of the antibacterial effect.

CONCLUSIONS

Homogenous vitreous structures of the $1.5Ag_2O$ 98.5% $[47B_2O_3$ $(53\text{-}x)CaO$ $xP_2O_5]$ systems were obtained for $0 \le x \le 10$ through the method of sub cooling of the melting.

The antibacterial inhibitions range is dependent of the P_2O_5/CaO ratio from the studied vitreous matrix that modifies the solvability of the samples, in the case of *Pseudomonas* and in the case of the *Staphylococcus aureus* strain.

The antibacterial effect is more pronounced in the case of *Pseudomonas* strain and it manifests from low phosphorus concentrations.

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