Iron Containing Glass and Vitreous Ceramic Powders Used for Medical Applications

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Abstract. Glass sample from $x\text{Fe}_2\text{O}_3 \cdot (80-x)\text{SiO}_2 \cdot 20\text{Al}_2\text{O}_3$ systems, where $x = 5, 10, 15, 20$ mol% were prepared by so-gel method at different pH (1.5 and 8.5) and termally treated of 500°C and 1200°C in order to investigate their interaction with biological tissue and with population of bacteria appering at the implant place.

The development of Staphylococcus aureus and Salmonella typhymurium bacterial populations in the presence of these powders has been investigated using a spectrophotometric method. The preparation pH effect is clearly evidenced only for $5 \leq x \leq 15$. The vitreous ceramic samples have slight effect upon population increase, more obvious for first three samples.

Keywords: glass, vitreous ceramic, sol-gel, bioactivity.

INTRODUCTION

Sol-gel method of preparation of vitreous powders is simpler than classical method (Jones et al., 2002) to melt and undercool obtaining oxide glasses, using low temperature. Heat treatment in a single step has the effect in vitro ceramic structure which occurred with significant changes by the crystalline phase appearance and physical properties change.

Oxide materials have been used with success in recent years for various medical purposes (Hupa and Karlsson, 2008) such as strengthening or replacing damaged tissues, or filling the cavity and on the surface tegument in the form of deposits for the controlled release of active substances. Oxide aluminum silicates systems obtained by sol gel method have been investigated (Leivo et. Al., 2006) due biocompatibility their particular body's soft tissues.

At the contact between material and body oxide there is a response by the appearance of an inflammatory reaction or trigger a bacterial infection.

Oxide powders vitreous and glass are often used as storage for active substances or ions (Simon et al., 2007) which is issued only from the surface and keeping them bioactive or the dissolution of powders in biological fluids. Active metal ion is introduced in glass structure by classical methods when possible or by ion exchange (Nunzio et. Al., 2003). Released in biological circuit may have an inhibitory effect on the development of bacteria in the environment or if opportunistic pathogens (Abou Neelie et. Al., 2005) or to the law of the electrostatic (Li and Logan, 2004).
MATERIALS AND METHODS

Reagent grade silicic acid (SiO$_2$(OH)$_{4,2x}$) and aluminum nitrate Al(NO$_3$)$_3$·9H$_2$O were used as starting materials to prepare by sol-gel process aluminosilicate samples as white powder. Iron doped aluminosilicate samples were obtained by adding increasing amount of Fe$_2$O$_3$ to the glass composition, resulting the final samples with 0, 5, 10, 15 and 20 mol % Fe$_2$O$_3$.

The MIC and MBC were determined using the broth microdilution method. Using Mueller Hinton broth, series of twofold dilutions of each tested compounds were performed in sterile 96-well microlitter plates 100 µl of each dilution, ranging from 4% to 0.125% (v/v), were mixed with an equal volume of bacterial suspension. Positive and negative growth controls were prepared.

The plates were incubated for 24h, at 37°C, under normal atmospheric conditions. The MIC was defined as the lowest concentration (highest dilution) of glass-ceramics that inhibited the visible growth (no turbidity), when compared to the control. Afterwards, 10µl of each well were transferred to Mueller Hinton agar plates and incubated for 24h, at 37°C. The lowest concentration associated with no visible growth of bacteria on the agar plates was considered the MBC. All dilutions were performed in duplicate and read using Unico 2100 spectrophotometer at 610 nm wavelength, using the reagent as a blank.

RESULTS AND DISCUSSION

The paper aim is to present a quantitative investigation of the way in which vitreous powders glass influence bacterial cultures. The interaction can occur as shown in any contact between bacteria and whiten the vitreous implant or the external application on the tegument surface.

In Fig. 1 optical density were represented graphically developments of biological samples for two-temperature heat treatment of oxide glasses based on silicon oxide. Such temperature have a significant difference effect on vitroceramics on Salmonella typhymurin bacterial populations only at 65 mol% SiO$_2$. With increasing molar content of iron in oxide samples, optical density biological samples treated at 1200° C increase for x > 15 mol% Fe$_2$O$_3$. 
For comparison (Fig. 1) there were represented optical density environment in the absence of nutrient compound in oxide (control variant the test) and that of the nutrient medium in which alcohol was added. Alcohol introduced proves to have an antibacterial easily seen by subtracting the sample turbidity. By comparison with the two lines, these compounds in glass solution prove to inhibit growth in the biological Salmonella sp. taken into study.

The preparation pH effect can be seen following the evolution of the two curves at the bottom of Fig.2.

The two parallel lines (Fig. 2) were drawn as a guide for the eye to be compared with biological samples containing oxide glasses. Dotted line represents the optical density of the environment in which nutrients were inoculated Staphilococcus aureus and we considered as samples standard. The continuing significance of the optical density of which standard biological alcohol was added to study the effect of the inhibitor on the development of this type of bacteria.
Optical density of biological samples that contain only glasses oxide prepared by sol-gel method at different values of pH increases slightly with the molar content of the samples. Effect of pH on the stability of the preparation of samples is insignificant, the lines that indicate turbidity their practical overlap.

When biological samples containing oxide compounds are added, their turbidity increases, and their density is greater than the sum of optical density taken two separate (and environmental Staphilocccus aureus and said medium and comprising oxide). The two curves located at the top of Fig. 2 show that the trend of increasing optical density with the molar content of iron in the samples is maintained.

CONCLUSIONS

Vitreous structures from $x\text{Fe}_2\text{O}_3-(80-x)\text{SiO}_2-20\text{Al}_2\text{O}_3$ system, where $x = 5, 10, 15, 20 \text{ mol\%}$, have been obtained by sol-gel method at very low temperatures comparing with classical method, and corresponding vitreous ceramic by termally treatment.

When introducing vitreous ceramic with above mentioned composition in biological samples they show an inhibitor effect on Salmonella typhymurin population grow.

The difference given by termally treatment effect of vireous ceramic is more obvious for 15 mol\% $\text{Fe}_2\text{O}_3$.

The of vitreous samples preparation pH has small effect only for low iron content on glass samples.

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REFERENCES


