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DEVELOPMENT AND APPLICATION OF BACTERICIDE GLASS IN POLYMERIC COMPOUNDS: EVALUATION OF BACTERICIDE PROPERTIES

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Abstract

In this paper are presented results of the evaluations of bactericide effect of a bactericide glass powder applied with sodium polyacrilate as and additive to LDPE (Low Density Polyethylene). The bactericide glass was produced performing an ionic exchange in a environment containing Ag^+ species. The microbiologic tests were performed applying the Agar Diffusion technique envolving *Staphylococcus aureus* bacteria. The incorporation of silver on the glass was evaluated qualitativaly by means of the EDS micro probe technique.

Keywords: ionic exchange, ionic sodium and silver, Master batch, bactericide glass.

INTRODUCTION

Polymeric compounds are object of studies for quite some time. The applications for this class of materials are considered broad, being used to manufacture countless types of products. Among the various sectors that employ polymeric materials as raw material are the hospital materials industry, food casings and hygiene-related products [(1)].

In these sectors, aggregating special properties to polymers corresponds to relevant innovations. Currently one of the special properties that have been sparking industrial interest is the microbiologic property. Many additives have been developed with the goal of aggregating bactericide, fungicide and algaecide properties to polymeric materials [(1-5)]. Such properties increase the value of determined products and also make them more effective and efficient.

In the quest for new additives many papers are being made employing new organic and inorganic compounds. One compound that has been standing out among the organic materials is the Triclosan® (Tri-chlorinated Phenol). For the inorganic compounds, zeolites impregnated with metallic ions. These additives are applied primarily in the manufacture of casings and home-utility products.

When it comes to biocide inorganic additives, the oligodinamic properties of some metals have been the base for development of many processes and products. Numerous metallic ions possess this property in relatively low concentrations, the order of parts per million thick, the top being silver, titanium, mercury and copper [(6-9)]. Among the various classes of materials, one studied has been the glass with such properties, aggregated by incorporation of metallic ions in its structure [(6, 8)].

Based on that effect, many papers have been written aiming the incorporation of these elements in ionic state to several types of materials, especially Ag^+ with bactericide effect, and Cu^+ with fungicide effect. In the incorporation of theses elements on glasses, a widely used process involves ionic exchange between the metallic ions and the sodium ion present in the vitreous matrix.

In this paper are presented recent studies regarding the application of vitreous matrix's bactericide additives, produced by ionic exchange, and applied directly on Low-Density Polyethylene. Part of the studies involved the evaluation of the contribution of the sodium polyacrylate compound on the bactericide properties of the polymer.

EXPERIMENTAL

Bactericide Additive

A glass with the following percentages in oxide weights was developed to be used as vitreous matrix for the bactericide additive: 72% SiO_2, 3% Al_2O_3, 5% CaO, 15% Na_2O, 5% Li O. This glass was melted to 1450 °C for 2 hours. The material was posteriorly submitted to grinding until reaching a granulometry of the order of 40 μm.

The ionic exchange was made in an ionic environment containing 10.0 g of glass, 10.0 g of Na_2NO_3 e 2.0 g of $AgNO_3$. The glass powder was added to the ionic environment and submitted to the exchange process at 430 °C, for 4 hours. After the ionic exchange, the glass powder was washed, dried and disaggregated, guaranteeing the initial granulometric distribution.

The samples were submitted to microbiologic tests with the objective of evaluating their respective bactericide effects. In all microbiologic tests 0.03 g of glass powder was used, and the test was the Agar-Diffusion, employing *Staphylococcus aureus* ATCC 25923 bacteria. The microbiologic tests were performed at 36 °C and submitted to 18 hours of incubation.

Additive application to PEBD

Once the glass with bactericide properties was obtained, it was incorporated to the polymeric material, Low-Density Polyethylene (LDPE), a homopolymer donated by the Ipiranga S.A. Company, added with sodium polyacrylate, donated by the BASF do Brazil Company.

The mixtures were made in a single-screw extruder, of laboratorial size. The different mixtures obtained in this step were submitted to Agar-Diffusion microbiologic tests using *Staphylococcus aureus* ATCC 25923 bacteria.

As misturas foram realizadas em uma extrusora monorosca, de porte laboratorial. As diferentes misturas obtidas nesta etapa foram submetidas a ensaios microbiológicos do tipo difusão em Agar empregando bactérias do tipo do tipo *Staphylococcus aureus* ATCC 25923.

RESULTS AND DISCUSSION

Figure 1a presents the microbiologic results for the glass after it was submitted to ionic exchange in an environment containing silver ions. The tests indicate the presence of significant bactericide properties on the glass, showing inhibition halos for the bacteria colonies. Figure 1b presents Energy Dispersive results (EDS) showing the presence of silver ions on the vitreous matrix. Such results indicate the possibility of obtaining a glass with bactericide properties due to the incorporation of silver species on its structure, exploring, this way, the oligodinamic properties of the Ag^+ species.

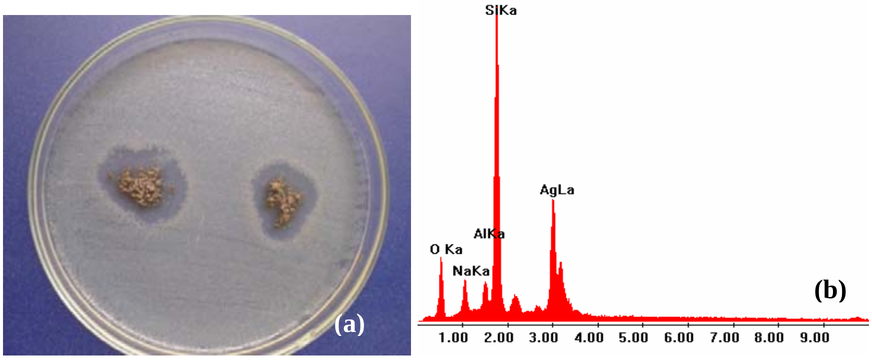

Figure 1 – (a) Microbiologic evaluation of bactericide glass applying the Agar Diffusion test using EC-type bacteria (b) Energy Dispersive results (EDS) for the bactericide glass.

Figure 2a presents the microbiologic results for the Low Density Polyethylene (LDPE) without application of additive, while Figure 2b show the ones for the sodium polyacrylate compound. Both test results indicate the absence of bactericide halos, which shows the absence of microbiologic properties for both materials. Considering the sodium polyacrylate it is observed its swelling (increase of volume). Such behavior is expect, given its high humidity absortion capability, up to aproximately 1000% of its volume when dry.

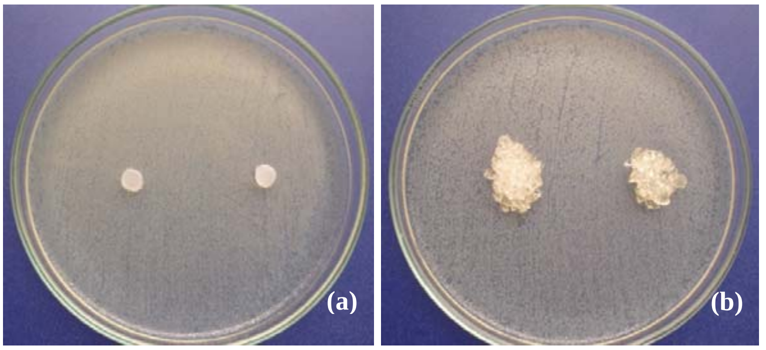

Figure 2 – Microbiologic evaluation of LDPE without application of additive and of the sodium polyacrylate, using Agar Diffusion test with EC-type bacteria. (a) LDPE (b) Sodium Polyacrylate

Figure 3a presents microbiologic results for the LDPE with addition of 5.0% of bactericide glass. The microbiologic test shows the presence of bacteria inhibition halos, which indicates the presence of bactericide properties on the LDPE. The inhibition halos' dimensions are generaly considered proportional to the bactericide effectiveness of biocide compounds, considering that the elements with active principle shall be diffused through culture, to conduce the bacteria to death.

The bactericide effect incorporated to the LDPE by the glass cannot be considered great, but satisfactory. The bactericide properties can't be desregarded, because depending on the application, they may be sufficent. Many products need bacteriostatic properties, not bactericide ones, and those suffice to inhibit the groth of bacteria on its surface.

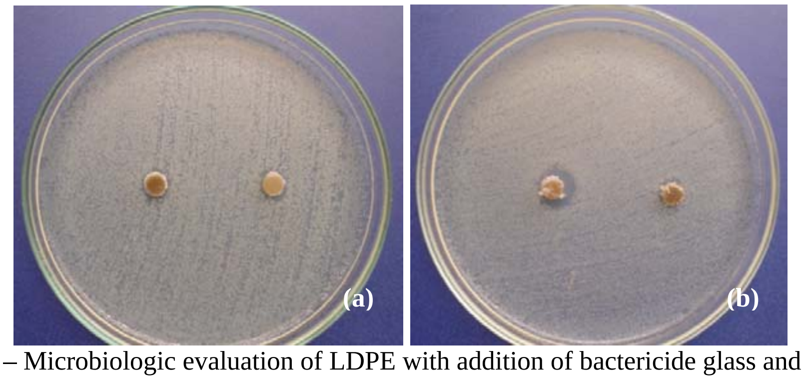

Figure 3 – Microbiologic evaluation of LDPE with addition of bactericide glass and sodium polyacrylate, applying Agar-Diffusion test using EC-type bacteria. (a) LDPE + 5.0 % of bactericide glass and (b) LDPE + 2.5 % of bactericide glass + 2.5 % of sodium polyacrylate.

Figure 3b presents microbiologic results for LDPE with addition of 2.5 % of glass and 2.5 % of sodium polyacrylate. The results show the presence of larger inhibition halos when compared to the LDPE without addition of sodium polyacrylate. Even with lower concentrations of glass the bactericide effects are more satisfactory, showing the presence of bigger inhibition halos, which means a greater bactericide efficiency for the LDPE.

The increase in bactericide efficiency to the LDPE with the incorporation of sodium polyacrylate may be associated with the ability of the sodium polyacrylate to attract water molecules. Such ability may be creating microchannels or micro water regions inside the polymeric matrix, hence favouring the percolation of the silver ions present in the vitreous matrix towards the polymers' surface. This way guaranteeing a higher concentration of ionic silver species for the diffusion in the culture environment.

The results obtained are strong indications that there are possibilities of produing a vitreous-based bactericide additive, having in its core composition the bactericide glass and the sodium polyacrylate compound. Certainly are need more detailed studies, envolving experimental planning in the determination of optimized compound concentrations, homogenization conditions for the polymeric matrix's compounds and the effect of the glass' particle size on the additive's bacteriricide principle.

CONCLUSION

The glass with silver incorporated to its structure, through ionic exchange, presents itself extremely efficient in the bactericide action against *Staphylococcus aureus* bacteria.

When employed as additive to the LDPE it aggregates bactericide properties to the polymer, therefore it can be considered a bactericide additive.

When employed simultaneously with the sodium polyacrylate compound the bactericide properties aggregated to the LDPE are improved, presenting greater biocide effects. These observations constitute indications of the presence of synergy in the bactericide properties when used both compounds as additives to the polymer.

Generally, the results indicated the possibility of producing an additive for polymeric materials produced based on vitreous bactericide material and sodium polyacrylate. Such information leads to new possibilities for future projects, applying proper experimental planning at the determination of concentrations, glass' particle size and optimized homogenization conditions for the development of this additive in industrial scale.

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