Silver foams with hierarchical pores for antibacterial activity

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Filters are mainly used to physically block objects or substances, to remove impurities such as dirt, bacteria or oil from the flow. Since open-celled foams have high specific surface area and permeability property, they are often preferred for flow-through applications as filters in where these internal surface properties can be exploited. Foams can be used in virtually any filtration field as wet or dry filters thanks to their excellent active surface area and porous structure**.** [1, 2] It is very important that the foams have good mechanical properties as well as they allow for a highly stable flow during the filtration. [3] Especially open cell metallic foams, have received considerable attention in recent years as materials that find use in various engineering applications. They are also suitable for use in the field of filtration to reduce the concentration of undesirable ions dissolved in water. [4] In applications intended to reduce the concentration of dissolved ions in water, open cell metallic foams with high liquid / gas permeability are used which allow liquid flow through micro and macro pores. [2, 3] Foams have been regarded as a convenient candidate for air filtration, drinking water purification, antibacterial purposes and for industrial and environmental filtration applications and previously many studies have been made for these purposes. [5] Microbial contamination from microorganisms causes various problems in human life. It is impossible to create a completely sterile environment to prevent infections, but it is possible to take precautions to prevent the increase in the number of microorganisms. Bacterias are the most common and most serious infections of microorganisms. As is known, ions of metals such as copper, zinc and silver have a strong antibacterial effect. [6] In order to combine and take benefit of these advantages of ionic silver and cellular structure of foam, researchers have also been focused on studies to obtain materials which have uniform microstructures with micro and macropores and large internal surface area. Since the cellular structure of the foam can be controlled by porosity, there are several methods that can be used for the fabrication of open celled silver foams having micro and macro pores throughout the foam. [7, 8] The primary objective of this study is to produce antibacterial effective foam structures with replication method following by chemical dealloying. For this purpose, production was started with alloying aluminium and silver metal, and then it was used to manufacture foams. Two different route were used as 5% HCl and 20% NaOH solution in order to observe the effect of dealloying environment on the microstructure and pore size distribution [9]. The codes were used to define samples as: AgAl is the foam resulting from infiltration of a packed bed of preforms with liquid AgAl alloy, after dissolution of the NaCl particles (with no further chemical treatment); Ag-HCl is the foam after HCl treatment; Ag-NaOH is the foam after NaOH treatment; Ag-sint is a foam resulting from sintering. Foams were analyzed by SEM, interconnected-bicontinuous structures with hierarchical pore sizes ranging from nanoscale to micron scale were obtained with both dealloying route. XRD analysis was carried out to determine phases the samples contain after the dealloying processes. With the detailed pore size distribution study, the contributions of the different scale pores to the foam porosity which sourced from alloy microstructure, infiltration process and the dealloying process were determined. Nitrogen adsorption/desorption isotherms were used to determine surface area, pore volume and nano pore size distribution. Multi point BET method was used to measure surface area of the samples. Pore volume and nanopore size distribution was carried out by Quantochrom software. In addition to characterisations were mention above, to evaluate the performance of the foams as a filter, antibacterial efficiency was investigated according to ASTM E2149 against Gram Positive (S. aureus) and Gram Negative (E. coli) bacterias. The effect of dealloying process and pore size distribution on antibacterial performance of the foam were investigated. After 24 hours, the foam dealloyed with NaOH exhibited a superior performance compared to the other foams, providing 99.99% reduction in both bacteria species. These promising results have shown that this process combination allows to tailor the pore size, distribution and porosity according to the intended area of use.

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Figures

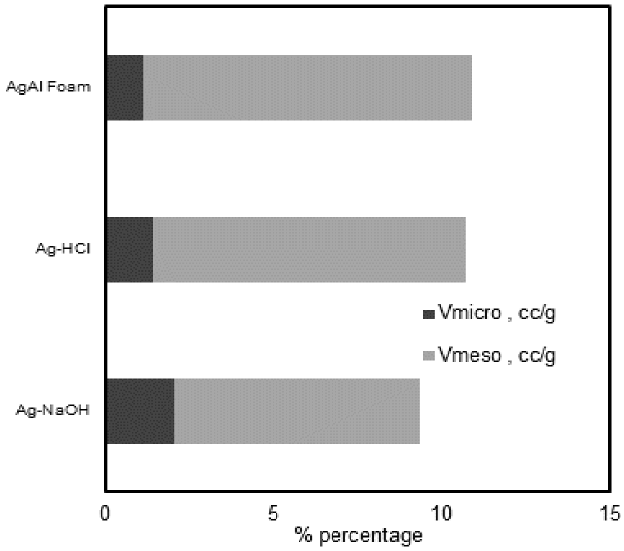

Figure 1. Contribution of micro and meso pores to total volume

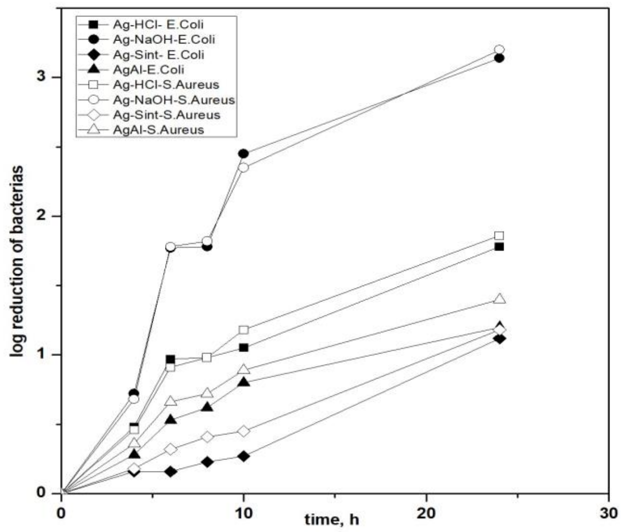

Figure 2. Experimental results for antibacterial activity were displayed as log reduction versus exposure time for AgAl, Ag-HCl, Ag-NaOH and Ag-Sint samples against E.Coli and S.Aureus.

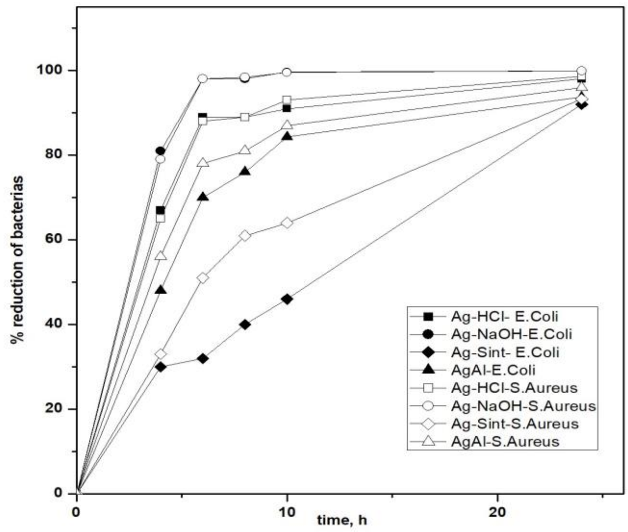

Figure 3. Experimental results for antibacterial activity were displayed as % reduction versus exposure time for AgAl, Ag-HCl, Ag-NaOH and Ag-Sint samples against E.Coli and S.Aureus.