Antibacterial and non-toxic $Ag-Al_2O_3$ layer for public space applications

Condello Maria[1], Meschini Stefania[1], Massimo Calovi[2], Stefano Rossi[2]

[1]National Center for Drug Research and Evaluation, National Institute of Health, Rome

[2]University of Trento, Department of Industrial Engineering, Trento

INTRODUCTION

The emergence and spread of the SARS-CoV-2 pandemic has forced attention to the realization of antimicrobial surfaces for public spaces, which do not require extensive use of disinfectants. In addition, infections caused by multidrug-resistant bacteria are a major public health problem. Their transmission is strongly linked to cross contamination *via* inert surfaces, which can serve as reservoirs for pathogenic microorganisms. To address this problem, antibacterial materials applied to high-touch surfaces have been developed.

Aluminium is one of the most used materials for the construction of surfaces and components in public spaces thanks to an interesting combination of properties:

-high specific strength
-thermal conductivity
-workability
-low density
-low cost
-pleasant appearance

Silver is the ideal candidate for the creation of anodized aluminium layers with antibacterial performance.

ANODIZED ALUMINUM

$Ag-Al_2O_3$ layer

SINGLE STEP CODEPOSITION PROCESS

THE AIM OF THIS WORK: evaluate both the possible alterations of the surface of silver anodized aluminum that could lead to nanomaterials and ion release and its correlation with the **POSSIBLE TOXICITY IN THE HUMAN EPIDERMIS**

RESULTS

Composite layer production by codeposition with Silver Nitrate

Table 1 Samples nomenclature, with relative $AgNO_3$ amount added to the H_2SO_4 anodization bath.

Anodization bath	$AgNO_3$ addition[g/L]	Sample nomenclature
20 wt.% H_2SO_4	0.00	X
	0.85	A
	1.70	B

Table 2 summarizes the thickness values of the three layers, obtained from 50 measurements per sample series.

Sample	Layer thickness [µm]
X	12.1 ± 0.9
A	12.7 ± 0.8
B	12.6 ± 0.4

Characterization by SEM

The modification of the sulfuric acid bath with silver nitrate does not seem to have altered the anodization process yield.

SEM observation exposure in climate chamber

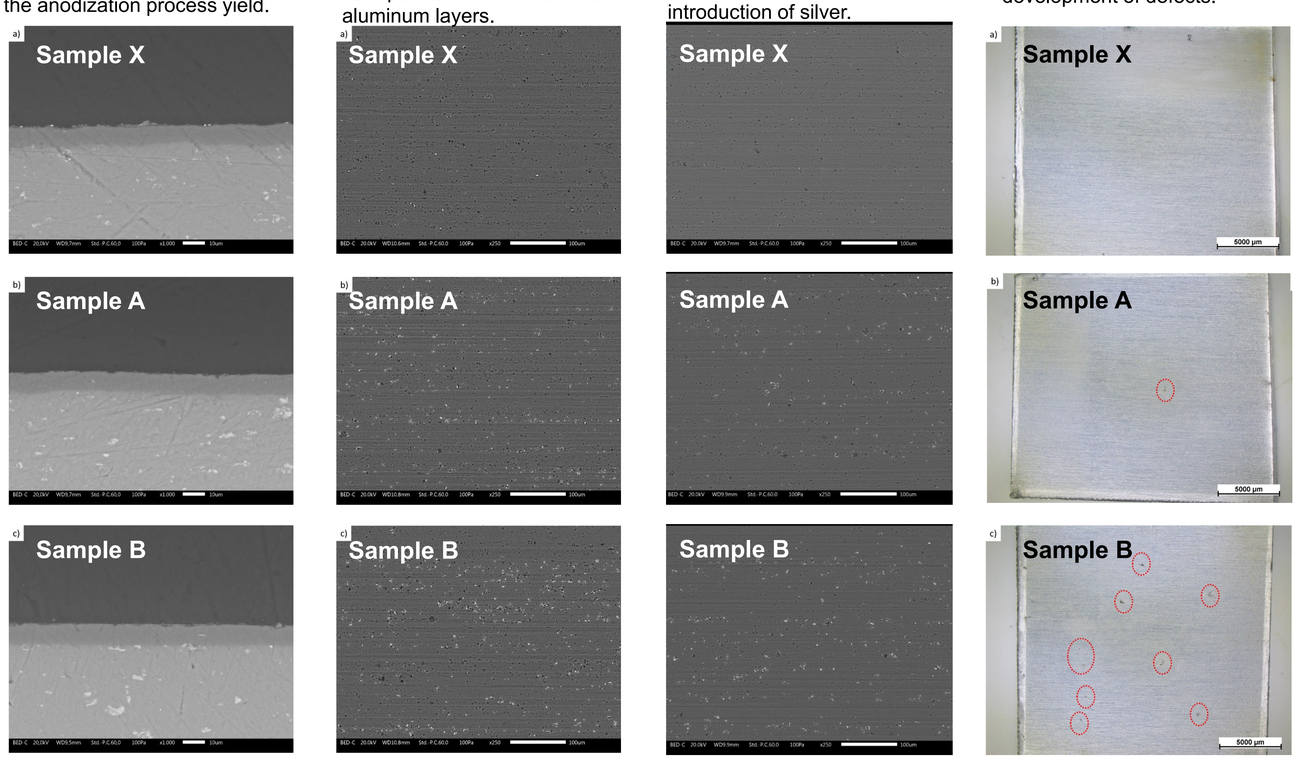
High thermal stability of Ag nanoparticles in anodized aluminum layers.

SEM observation after UV-B radiation

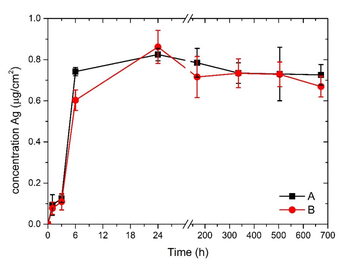
The layer of Al_2O_3 does not suffer from UV-B exposure and is not affected by the introduction of silver.

Optical observation after Kesternich test

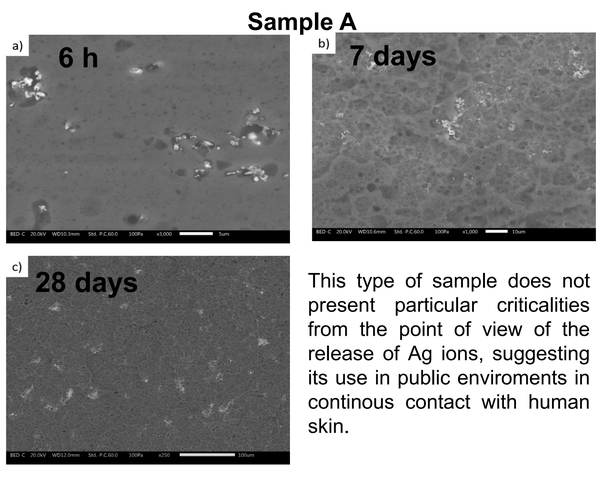
Negative effect introduced by silver, which favors the development of defects.



Ag ions release



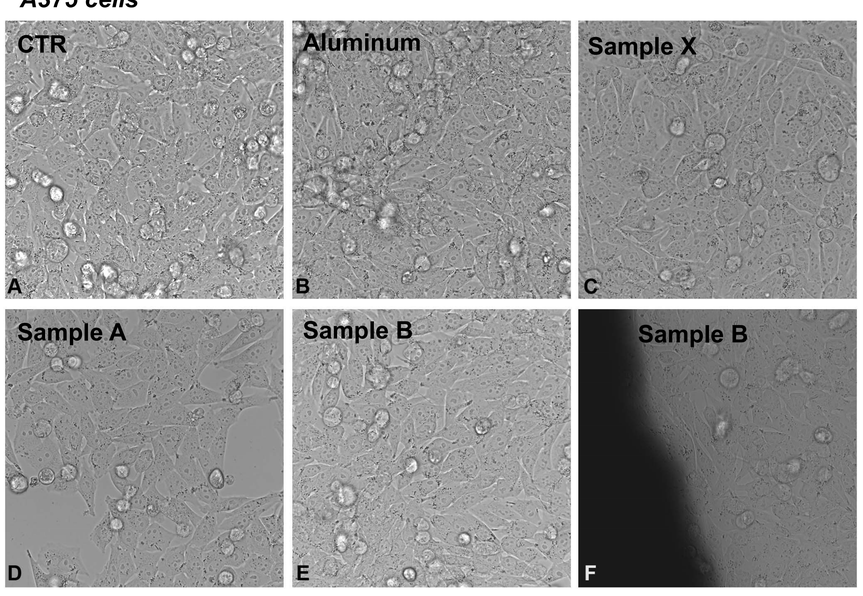
The sudden release of silver ions is due to the rapid dissolution of the composite layer in contact with acid solution.

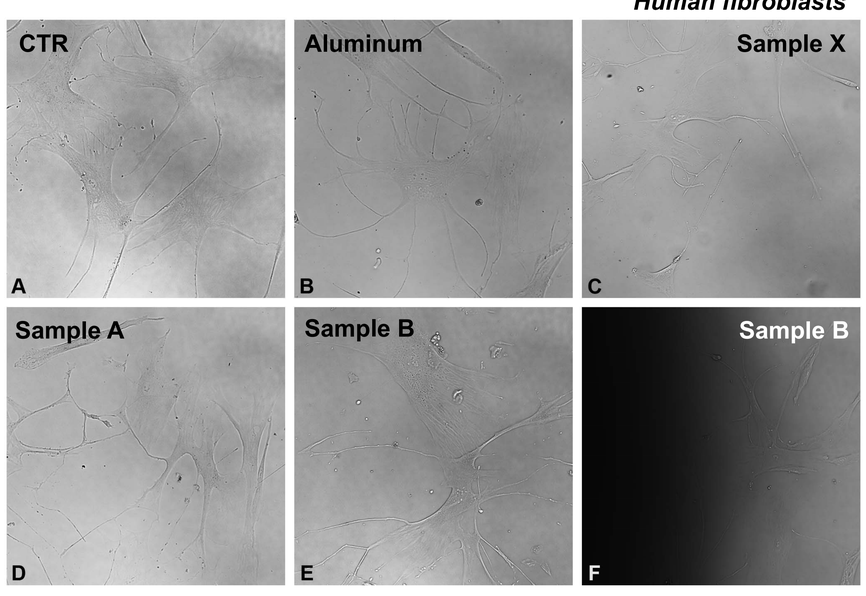


This type of sample does not present particular criticalities from the point of view of the release of Ag ions, suggesting its use in public enviroments in continous contact with human skin.

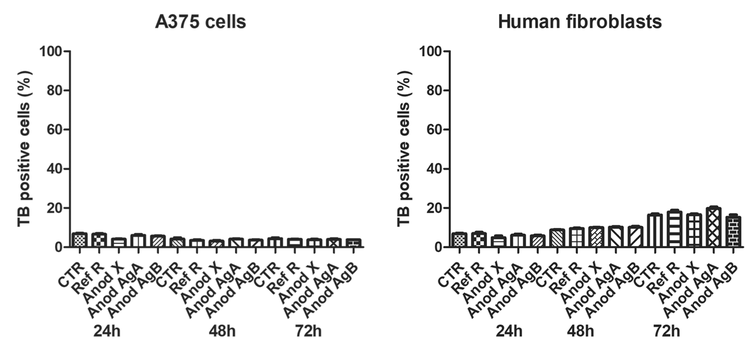
Thus, the release of silver ions was assessed by placing the samples in contact with a lactic acid solution simulating human sweat. To evaluate the possible toxicity induced by contact with the surfaces, cytotoxicity resulting from continuous exposure of tumor and normal human cells to anodized aluminum surfaces with and without silver was studied. The presence of silver ions release in the medium in which the cells were seeded simultaneously with the aluminum samples, anodized aluminum, silver content in anodized aluminum at a low concentration (sample A) and a high concentration (sample B) was also evaluated.

Morphological analysis was performed by light microscopy





In vitro toxicity assay



CONCLUSIONS

These analyses showed the good compatibility beteew Ag and the alumina matrix, whose durability performances were not particularly influenced by silver. Furthermore, the composite layers did not express relevant cytotoxic activity ensuring the possible use of this material in applications in close contact with humans. This work presents an innovative material that can be used in public spaces, thanks to its interesting combination of high durability and low cytotoxicity.

Innovative Codeposition of a $Ag-Al_2O_3$ Layer: An Attractive Combination of High Durability and Lack of Cytotoxicity for Public Space Applications. Massimo Calovi , Stefania Meschini, Maria Condello, Stefano Rossi. ACS Omega 2022 Jul 15;7(29):25650-25662.doi:10.1021/acsomega.2c02872. eCollection 2022 Jul 26.