Effect of silver ion incorporation into a bioactive glass surface on the adsorption of albumin

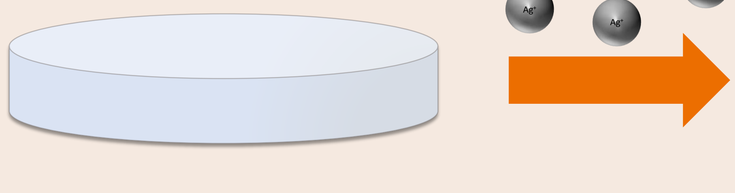
Politecnico di Torino
Department of Applied Science and Technology

ESB21 September 2021

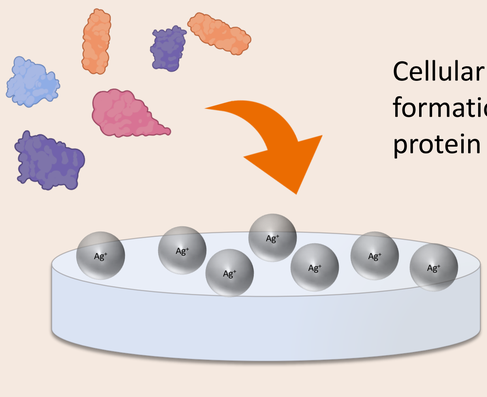
# *Effect of silver ion incorporation into a bioactive glass surface on the adsorption of albumin*

***Barberi, J.*** *Giovannozzi, A.M. Mandrile, Miola M. L. Napione, L. Vitale, A. Spriano S.*

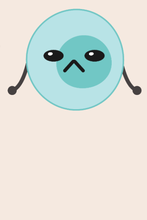
Bioactive glasses are able to promote tissue integration, such as osteointegration, and hydroxyapatite precipitation. Unfortunately, also biofiml can form on their surfaces.
Thus, silver ions are incorporated in bioactive glasses surfaces for achieving antimicrofouling properties.



How these surface treatments change protein adsorption?

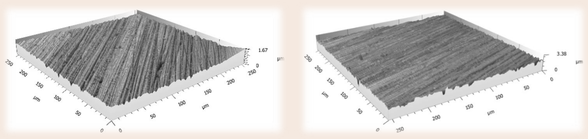


Cellular response and biofilm formation are driven by the protein layer on biomaterials



## The topography is unchanged by the surface treatments

SBA2: $S_a$= 81 nm  Ag-SBA2: $S_a$ = 120 nm

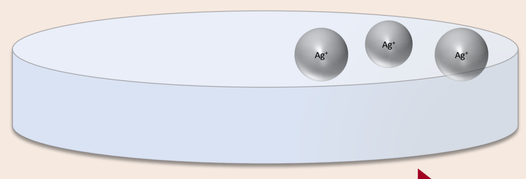


*Surface 3D images by confocal microscopy and surface roughness*

## Silver is succesfully incorporated into the glass

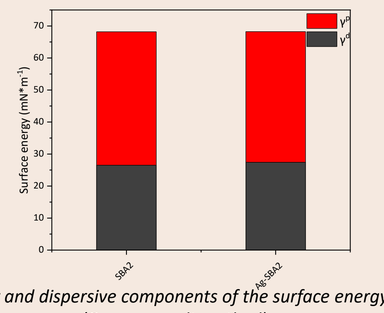
| Atomic % | Si | O | Ca | Na | Ag | C&Others |
|---|---|---|---|---|---|---|
| SBA2 | 5.08 | 37.61 | 7.67 | 2.88 | n.d. | 46.76 |
| AgSBA2 | 11.96 | 41.8 | 2.91 | 2.95 | 7.03 | 33.35 |

*Surface chemical composition (X-ray photoelevtron spectroscopy)*



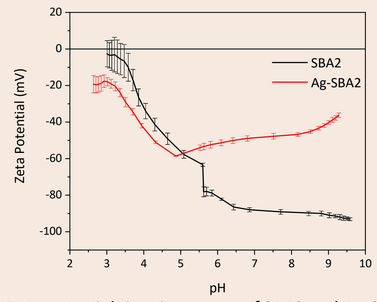
## Both surface energy, regarding dispersive and polar components, and the water contact angle are unaffected

| | Contact angle |
|---|---|
| SBA2 | 22° |
| Ag-SBA2 | 22.33° |

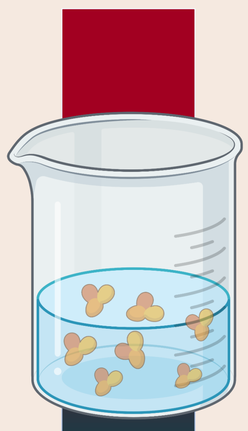



*Polar and dispersive components of the surface energy (Owens-wendt method)*

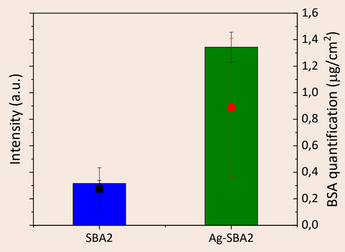
## Ag-SBA2 has a more positive surface at basic pH thanks to $Ag^+$ ions




*Zeta potential titration curves of SBA2 and Ag-SBA2*

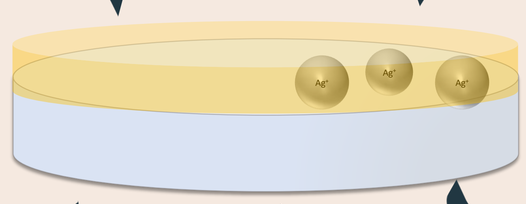


## Quantification of the adsorbed albumin by different methods (chemical assay, fuorescence and XPS) shows that Ag-SBA2 can adsorb a slightly higher amount of protein

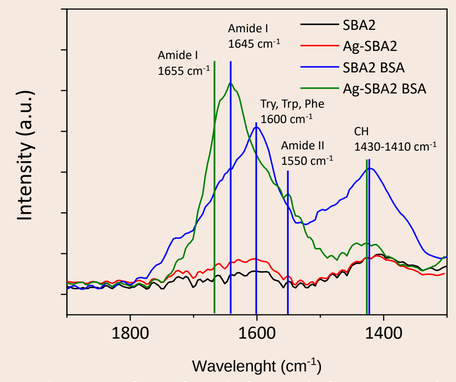



| | N% |
|---|---|
| SBA2 | 2.01 |
| Ag-SBA2 | 9.01 |

*Protein quantification by fluorescent intensity (rodhamine-conjugated BSA, bars) or bichinconininc acid assay (BCA, dots)*



## The redshift of the Amide I peak on Ag-SBA2 indicates a partial unordering of the α-helical structure with respect to the protein adsorbed on SBA2




*FTIR spectra in the Amide I region for surfaces before and after protein adsorption. Relevant deconvoluted peak positions are highlighted*

## After BSA adsorption, the shift of the IEP towards the one of albumin confirms the presence of the protein on both surfaces




*Zeta potential titration curves of SBA2 and Ag-SBA2*

## Both surfaces showed similar coverage of the protein layer, which is homogeneous



*Fluorescent images (200x) of SBA2 (left) and Ag-SBA2 (right) after BSA adsorption*

## Surface potential immagine (Kelvin Probe – AFM) can highlight both the formation of the protein layer (lighter areas) and the one of the silica gel (darker areas)




*Surface potential images of SBA2 (left) and Ag-SBA2 (right) partially covered by BSA*

## Materials

Glass substrates (disks, ϕ = 1cm; grit with SiC paper up to 1000) :

- SBA2 (mol %: 48% SiO2, 18% Na2O, 30% CaO, 3% P2O5, 0.43% B2O3, 0.57% Al2O3)
- Ag-SBA2: SBA2 soaked in 0.03M $AgNO_3$ for 1h at 37°C

Protein solution: bovine serum albumin (BSA) 7in PBS 20 mg/ml, pH 7.4.

## Bibliography:


- K. Zheng et al. Applied Materials Today 15 (2019) 350–371
- M. Miola et al. Biomedical Materials 10 (2015) 055014


## Contact:

jacopo.barberi@polito.it

## Conclusion

Silver doping of a bioactive glass does not affect much some surface properties which are pivotal for protein adsorption, such as topography, wettability and surface energy. Still, at physiological pH, the surface is less negatively charged. As consequence, the Ag-SBA2 can adsorb more albumin thanks to interactions between the negatively charged protein surface (-$COO^-$ groups) and the positive metal ions, $Ag^+$. The stronger interaction results also in a partial denaturation of the protein on the surface.
Knowing how antibacterial surface modifications alter the formation of the protein layer can improve the optimization of such treatments in order to elicit a proper biological response.