Antibacterial activity/Bioactivity of SiO_2, TiO_2, IrO_x inorganic and hybrid coatings

Crina Anastasescu [1], Diana Pelinescu [2], Jose Maria Calderon-Moreno [1], Veronica Bratan [1], Robertina Ionescu [2], Madalin Enache [3], Ioan Balint [1], Ileana Stoica [2] and Mihai Anastasescu [1]

[1] "Ilie Murgulescu" Institute of Physical Chemistry of the Romanian Academy, 202 Spl. Independentei, 060021 Bucharest, Romania

[2] Faculty of Biology, Intrarea Portocalilor 1-3, Sector 5, 060101 Bucharest, Romania

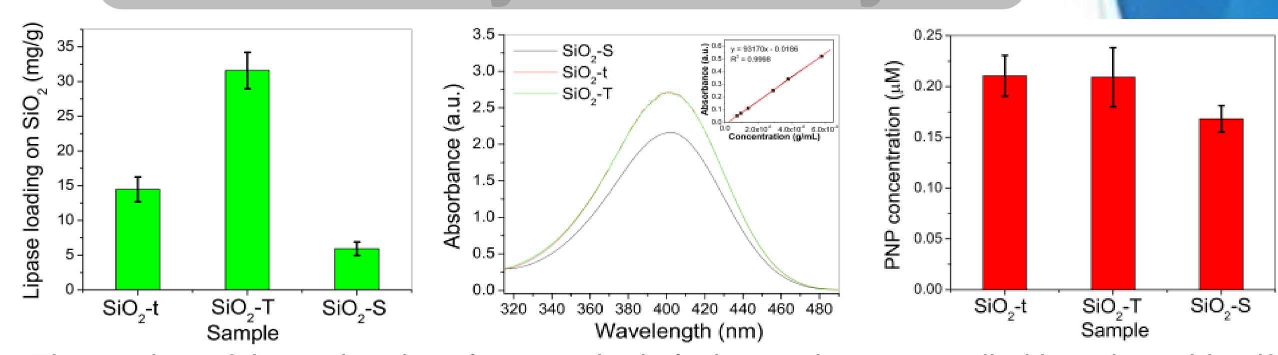
[3] Institute of Biology of Romanian Academy, 296 Splaiul Independenţei, 060031 Bucharest, Romania

*manastasescu@icf.ro

AIM

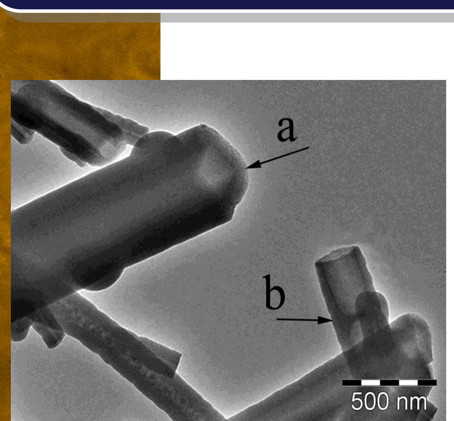
- Valorization of sol-gel bioactive materials
- Development of SiO_2, TiO_2, IrO_x oxide matrices with intrinsic / induced bioactivity
- Immobilization of enzymes on the sol-gel inorganic carriers
- Antibacterial and biocatalytic assays on the engineered materials and their hybrid derivatives

SiO_2/hibrids biocatalytic activity

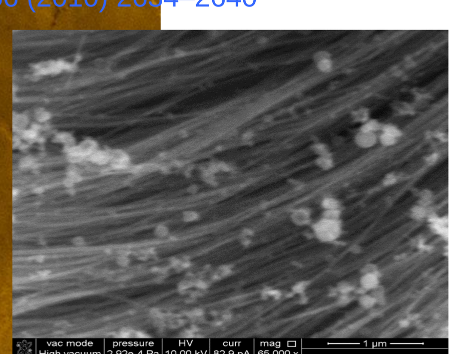


- The product of the p-nitrophenyl acetate hydrolysis reaction was studied in order to identify the highest enzymatic activity of the developed lipase–SiO_2 hybrid structures;
- Despite the greater amount of lipase loaded on larger tubes (SiO_2-T), the amount of p-NP (hydrolysis reaction product) obtained in the presence of immobilized lipase on thinner tubes (SiO_2-t) is slightly higher

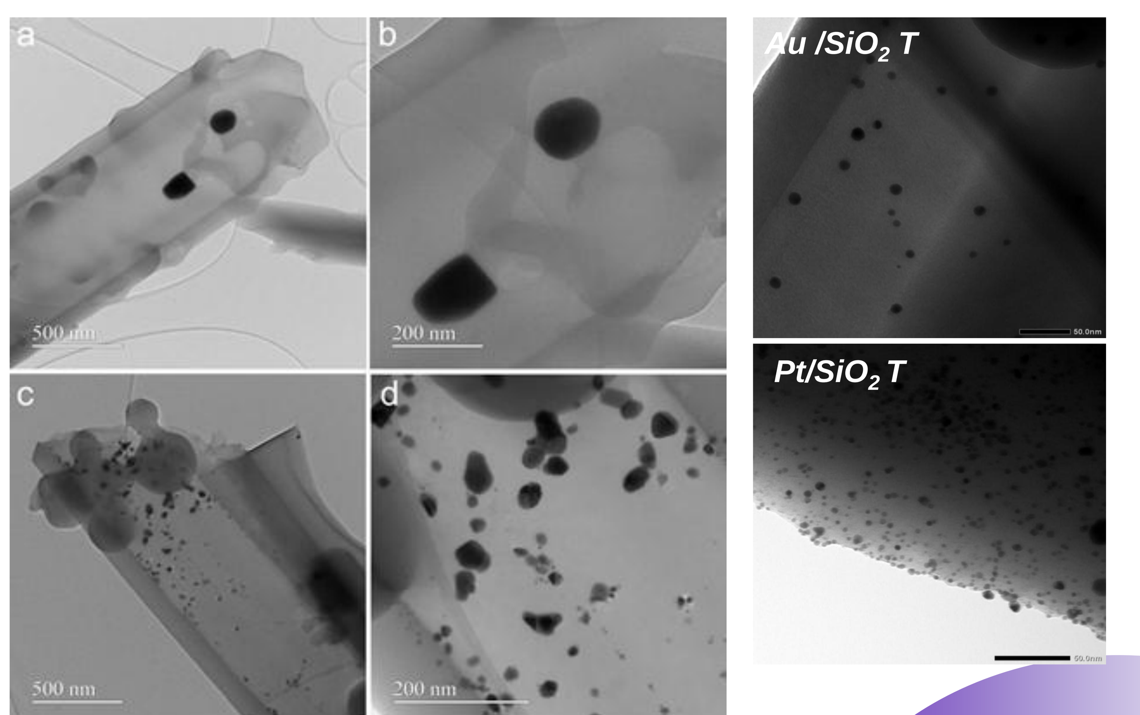
SiO_2 nanotubes bare and modified with Au and Pt NPs



C.Anastasescu, et al, J.Non.Cryst.Solids 356 (2010) 2634–2640



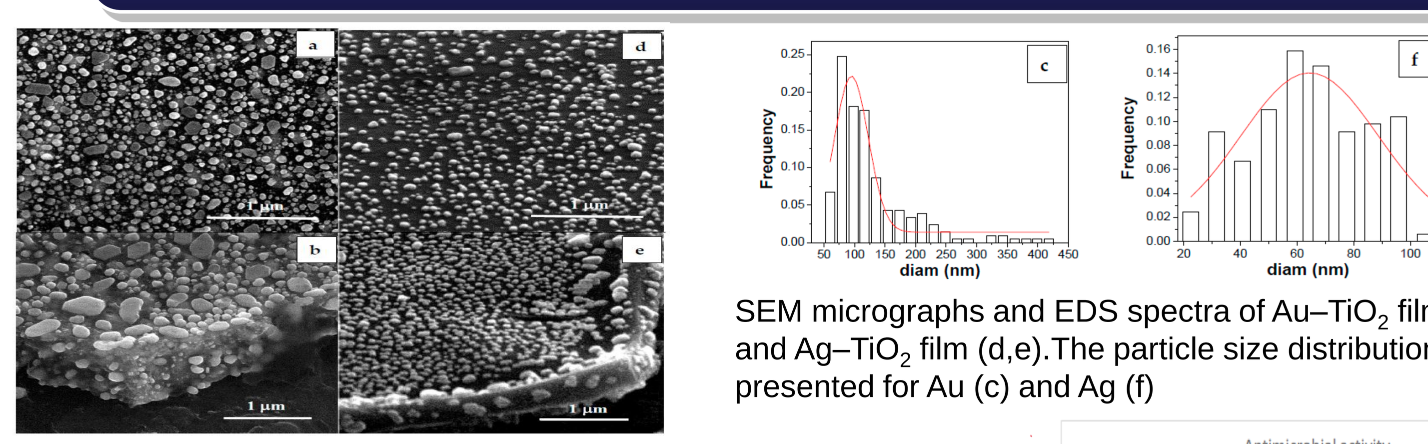
C.Anastasescu, InTechOpen, (2019), ISBN 978-1-78984-617-1

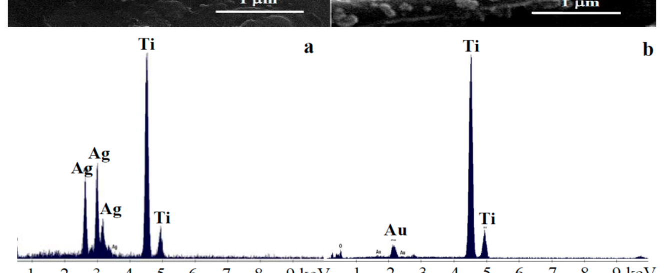


TEM images of the SiO_2 powders modified with metal nanoparticles: $AuSiO_2$ (a,b) and $PtSiO_2$ (c,d)

D. Pelinescu, et al, Gels 2023 9(8) 650

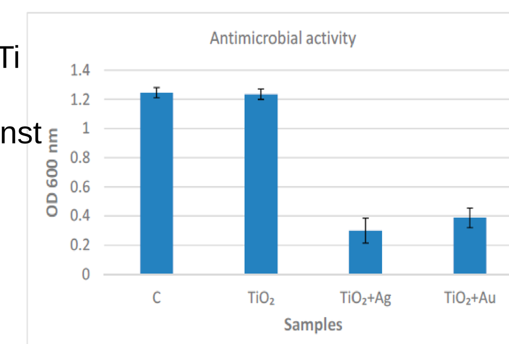
Bioactive coatings based on TiO_2 modified with Au and Ag NPs





SEM micrographs and EDS spectra of Au–TiO_2 film (a,b) and Ag–TiO_2 film (d,e).The particle size distribution is presented for Au (c) and Ag (f)

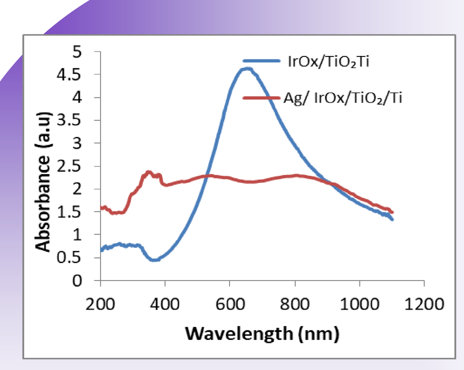
Ag–TiO_2/Ti and Au–TiO_2/Ti show significant antimicrobial activity against M. Lysodeicticus. The overall activity sequence: Lys/TiO_2/Ti > Lys/Au–TiO_2/Ti Lys/Ag–TiO_2/Ti.



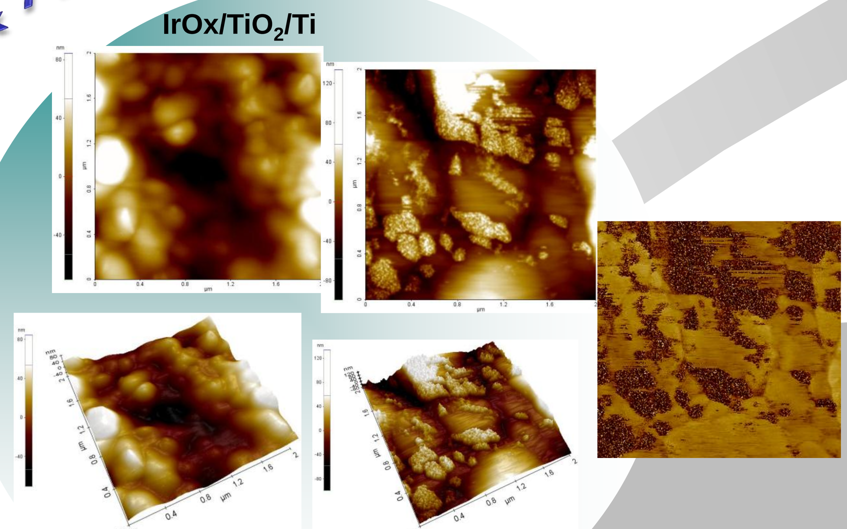
Microbial growth of M.Lysodeicticus over the TiO_2-based coatings of titanium

E. Chifor, C. Anastasescu, et al; Nanomaterials, 2022, 12, 3186

Coatings based on IrO_x/TiO_2/Ti, Ag/IrO_x/TiO_2/Ti

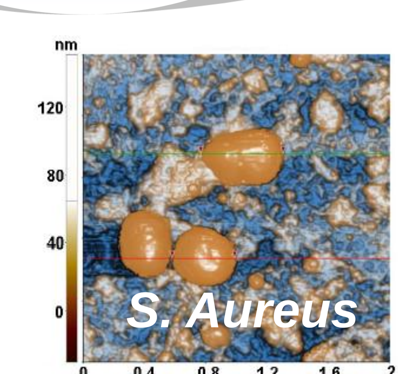


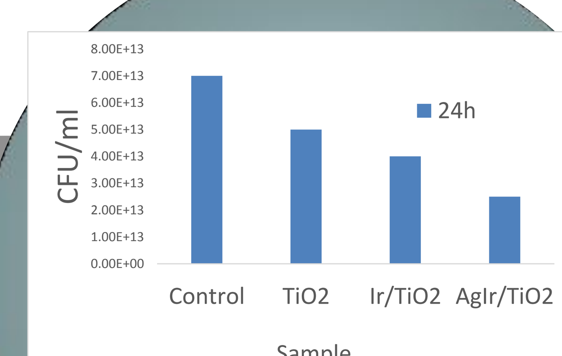
UV Vis spectra of the coatings: $IrO_x/TiO_2/Ti$ Ag/$IrO_x/TiO_2/Ti$



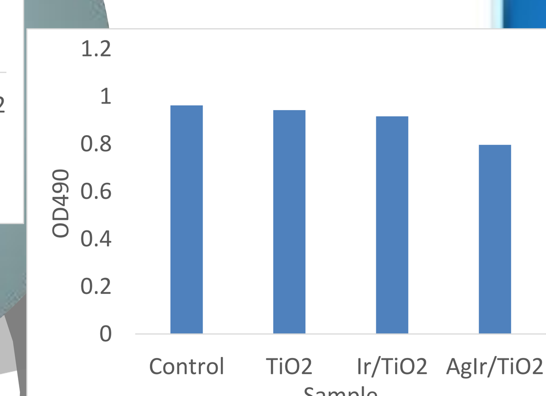
IrOx/TiO2/Ti

Ag/IrOx/TiO2/Ti foil



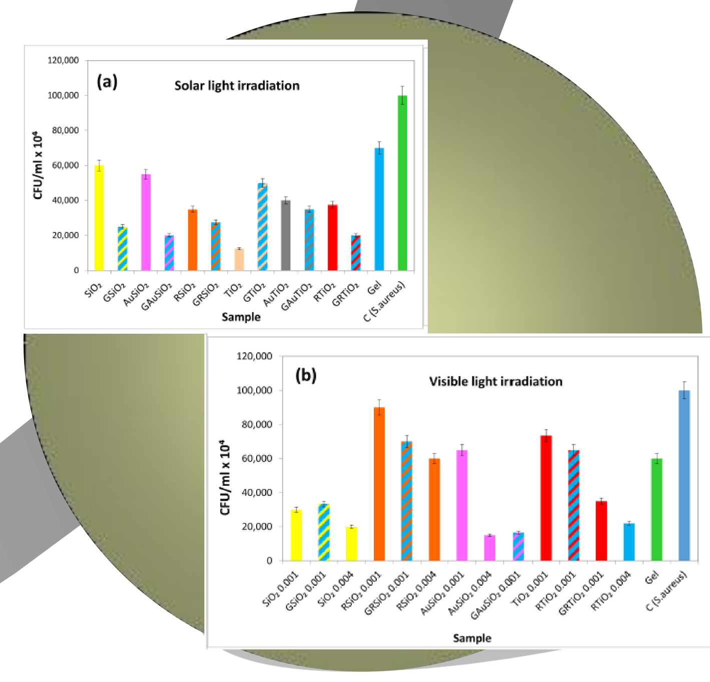


Cell viability registered after 24h for S. aureus in the presence of the target samples



Microbial biofilm formation after 48h

Bioactive SiO_2 and TiO_2 based materials



Antibacterial activity of the selected samples against S. aureus under solar light exposure (AM 1.5) for 30 min (**a**); antibacterial activity of the selected samples (0.001 g and 0.004 g) under visible light exposure (> 420 nm) for 30 min (**b**).

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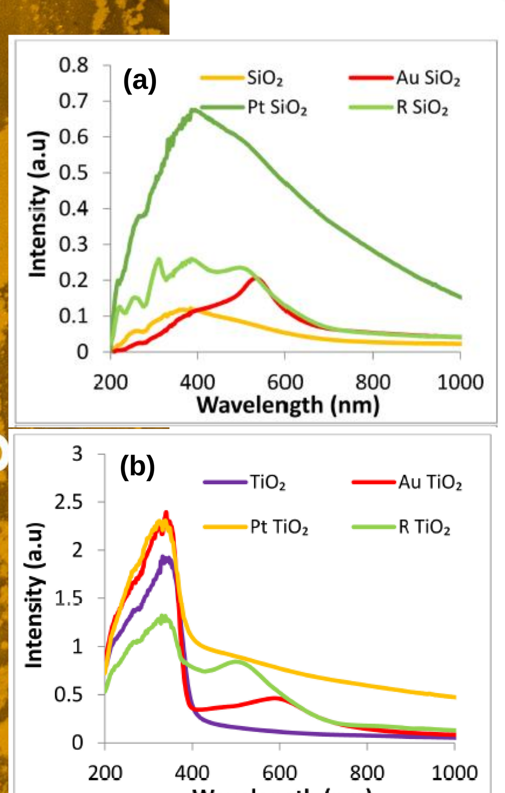
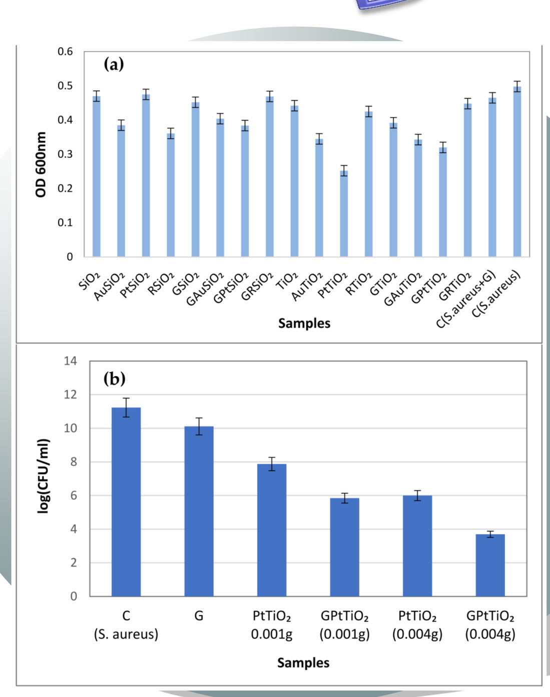
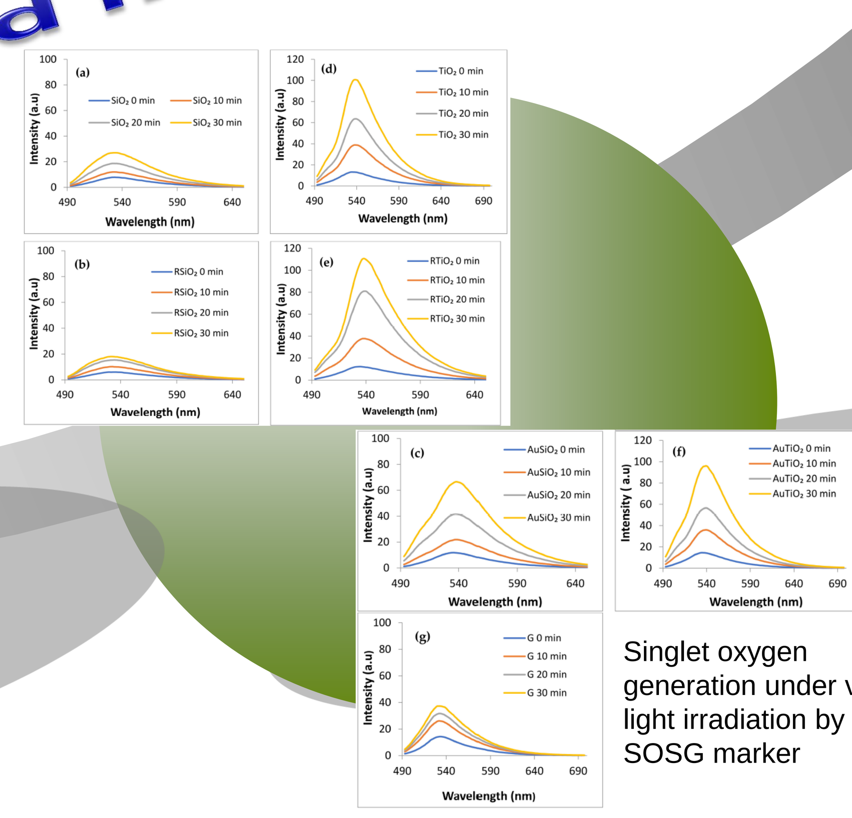


Comparative UV–Vis spectra SiO_2 (a) and TiO_2 (b) based-powders in the range of 200–1000 nm



Antibacterial activity of all investigated samples against *S. aureus* in the dark, quantified as the optical density (**a**); cell viability (logarithm of the colony forming units) over gel sample and different amounts of $PtTiO_2$ materials, in standalone forms or embedded in gel (**b**).



Singlet oxygen generation under visible light irradiation by using SOSG marker

Both unmodified SiO_2 and TiO_2 samples show insignificant antibacterial activity (upper figure). The lowest cellular viability relative to the control (*S. aureus*) was registered for the $PtTiO_2$ sample, the gel embedding of $PtTiO_2$ powder has a lower antibacterial effect

CONCLUSIONS

✓ Sol-gel is a versatile method for developing various inorganic and hybrid matrices
✓ SiO_2 nanotubes are appropriate for enzyme immobilization, their hybrids working as efficient biocatalysts
✓ Bioactive coatings based on nanostructured TiO_2 modified with noble metal nanoparticles and lysozyme show antibacterial activity
✓ $PtTiO_2$ powder emphasizes a strong antibacterial effect against *S. aureus* in dark while tubular SiO_2 acts against microbial cell due to the generation of singlet oxygen under visible light irradiation

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