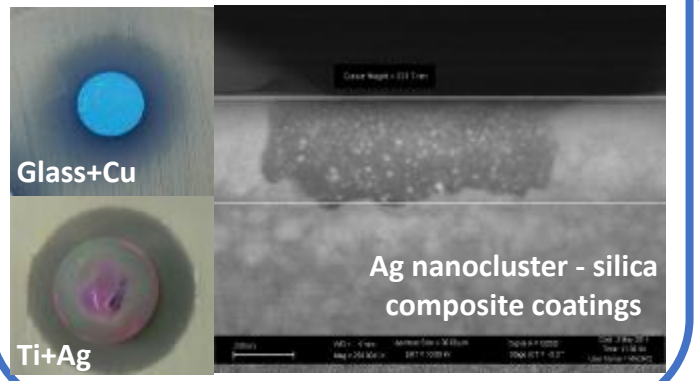
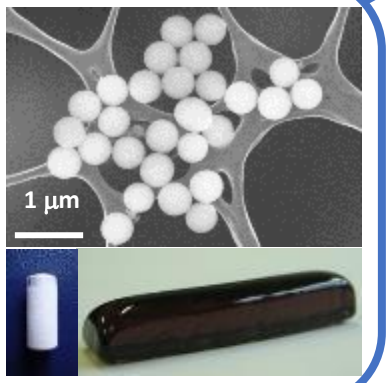
http://www.composites.polito.it

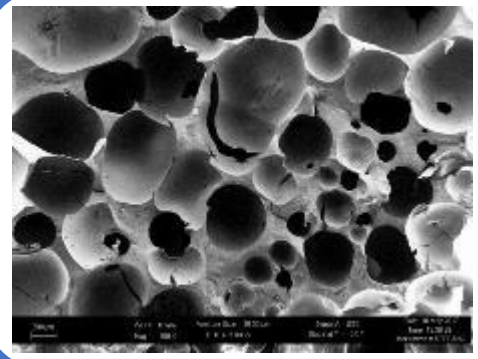
Antibacterial-Antiviral materials and layers



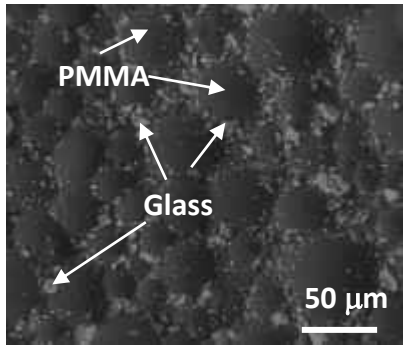
Tailored bioactive glasses for hard and soft tissue regeneration



Bioactive glass-based scaffolds for bone tissue regeneration

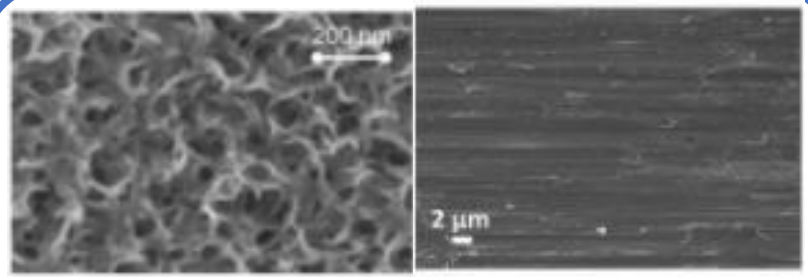


Multifunctional composite bone cement

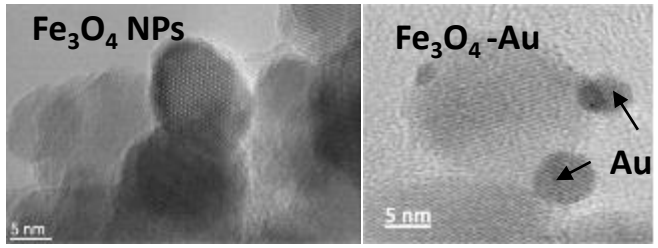


GLANCE
GLASSES, CERAMICS AND COMPOSITES

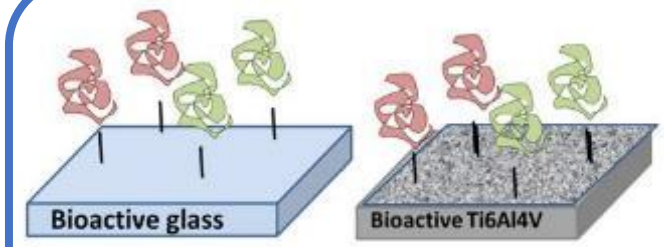
Ti modifications for hard and soft tissue regeneration



Magnetic-plasmonic NPs for tumor theranostics - gene therapy



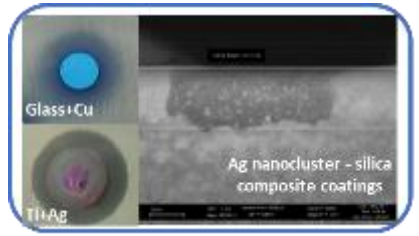
Surface functionalization & coating



Politecnico di Torino
1859

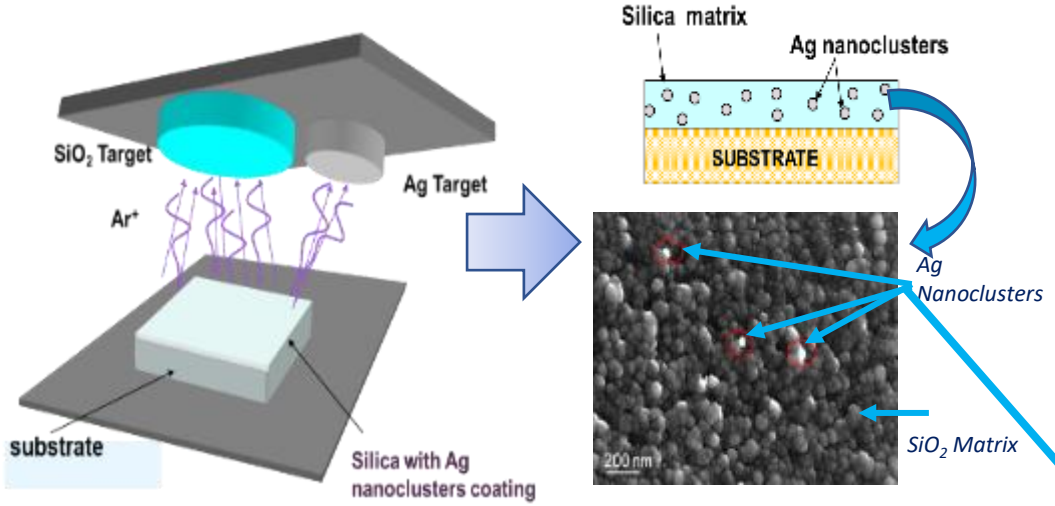
chimica fisica materiali
DiSAT
scienza e ingegneria

Antibacterial-Antiviral materials and layers



Antimicrobial/Antiviral Nanostructured Composite Coatings

Co-sputtering deposition of SiO_2 and Ag



http://www.j-tech.polito.it/

Metal nanoclusters (Ag, Cu, Zn, …) and matrices (SiO_2 , ZrO_2 …)

Flexible and well adherent coating
No dispersion of nanoclusters in the environment
"Green" deposition method, easy to be industrially scaled-up
Suitable to all the types of surfaces/materials
Thermal resistance up to 450°C

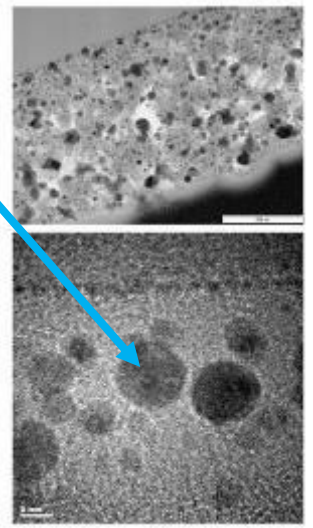
https://www.youtube.com/watch?v=4cVXhbCq1mM

https://www.youtube.com/watch?v=CfmAWJIkHNI

ANTIVIRAL EFFECT
Reduction of titre of SARS-CoV-2 virus to zero

2019 *Ferraris M., Balagna C, Perero S., Method for the application of an antiviral coating to a substrate and relative coating WO2019/082001*

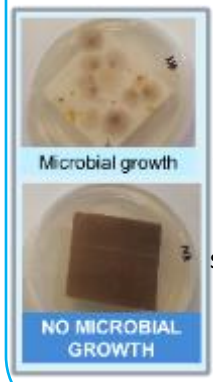
https://doi.org/10.1016/j.ceram.2020.100006



Face masks, Textiles & Personnel protective systems

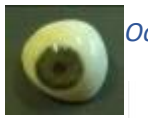
ANTIVIRAL EFFECT
Reduction of titre of SARS-CoV-2 virus to zero

Air filtration



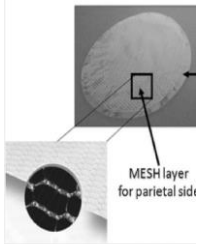
Strong virucidal activity against **SARS-CoV-2 virus,** respiratory syncytial virus &influenza virus type A

Biomedical application



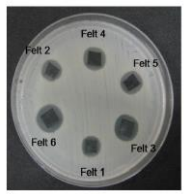
Ocular prosthesis

Temporary fixation devices



Mesh for abdominal wall repair

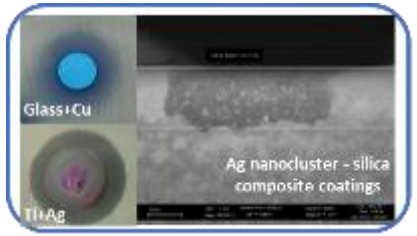
Mobile Phones



Aerospace applications

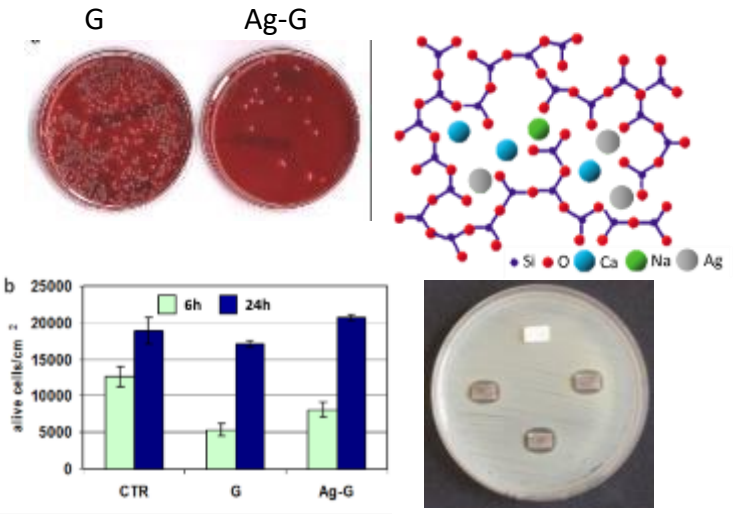
Inflatable Modulus

Antibacterial materials



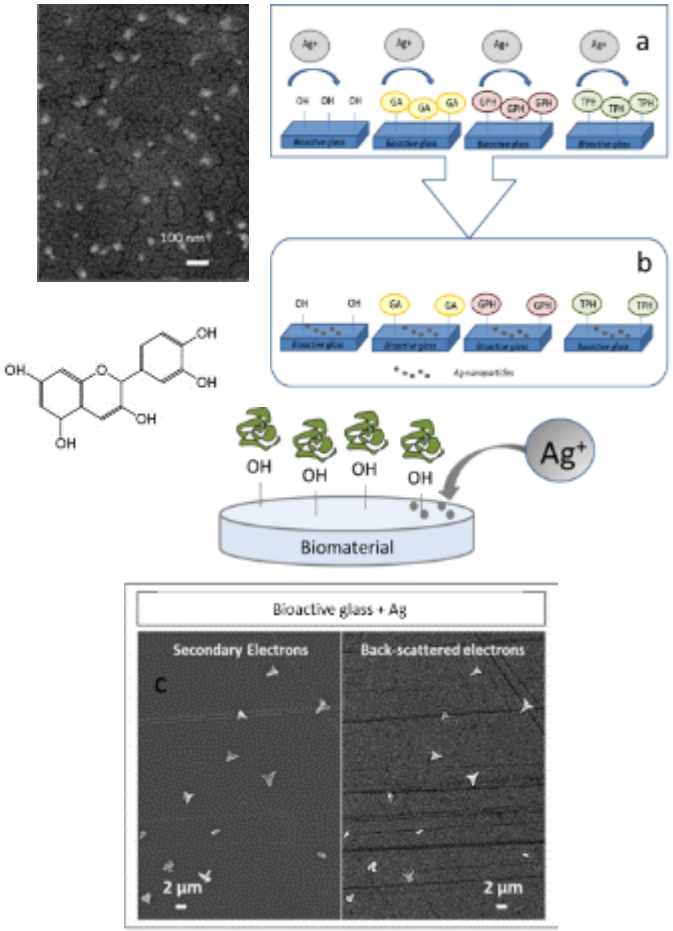
Biomaterials with bioactive and antibacterial properties for bone implant applications

Silica based bioactive glasses/glass-ceramics, containing antibacterial elements (such as Ag, Cu, Zn, …)



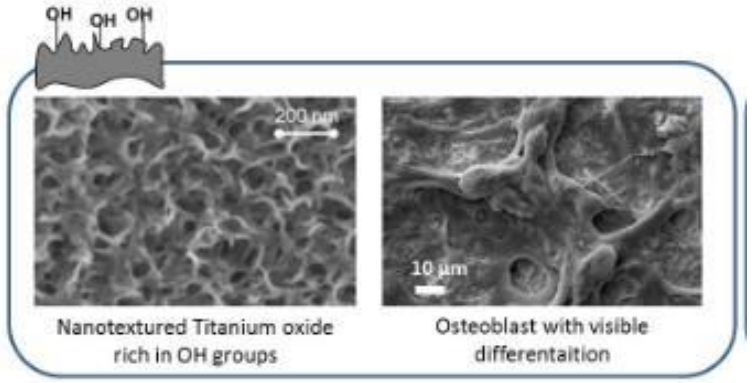
The processes to introduce the antibacterial element can be easily applied to glass powders, glass-coated devices, glass and glass-ceramic scaffolds for tissue engineering.

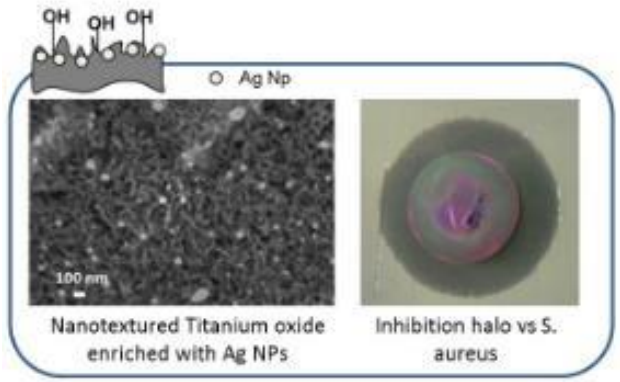
In situ reduction of antibacterial nanoparticles on glasses surface using green reduction agent (e.g. gallic or tannic acid, and natural polyphenols).



Bioactive and antibacterial titanium surfaces

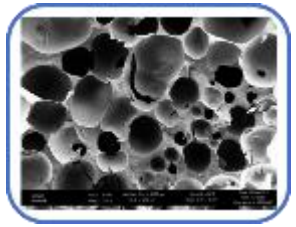
Surface hydroxyl groups of chemically treated Ti alloys can be effectively exploited for surface grafting of various biomolecules. The addition of a silver salt in the treatment solution induces surface silver enrichment conferring antibacterial properties to the bioactive metal.





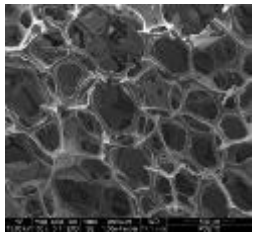
Bioactive glass-based scaffolds for bone tissue regeneration

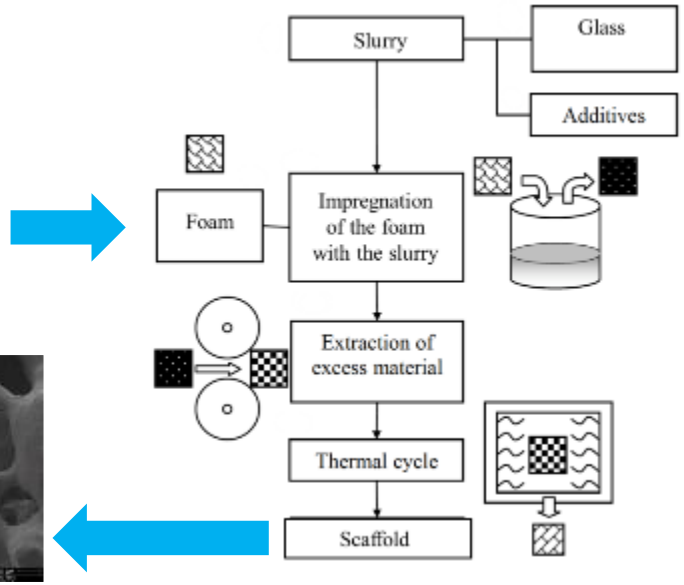
Applications: repair of bone defects (small, mid and large size) in orthopaedics and dentistry; tissue engineering



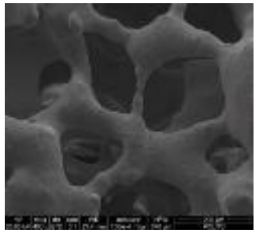
- **TEMPLATE-BASED METHODS**

Sacrificial POLYMERIC SPONGE or STALE BREAD



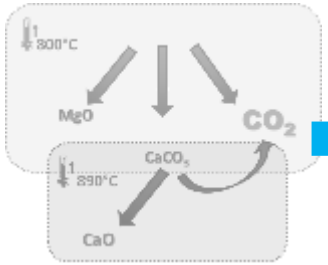


Sintered glass or glass-ceramic scaffold



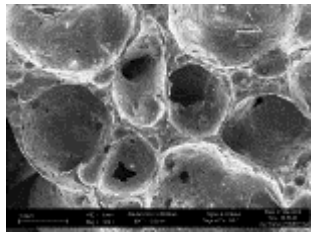
- **FOAMING METHODS**

Thermal degradation of DOLOMITE from quarry waste



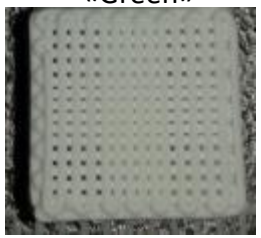
- Generation of macropores

- Supply of CaO and MgO



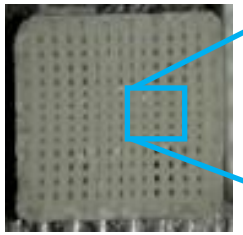
- **ADDITIVE MANUFACTURING**

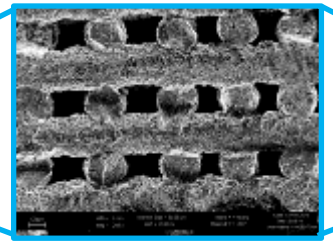
«Green»



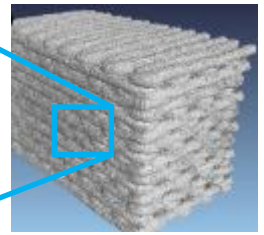
Heat treatment

Sintered

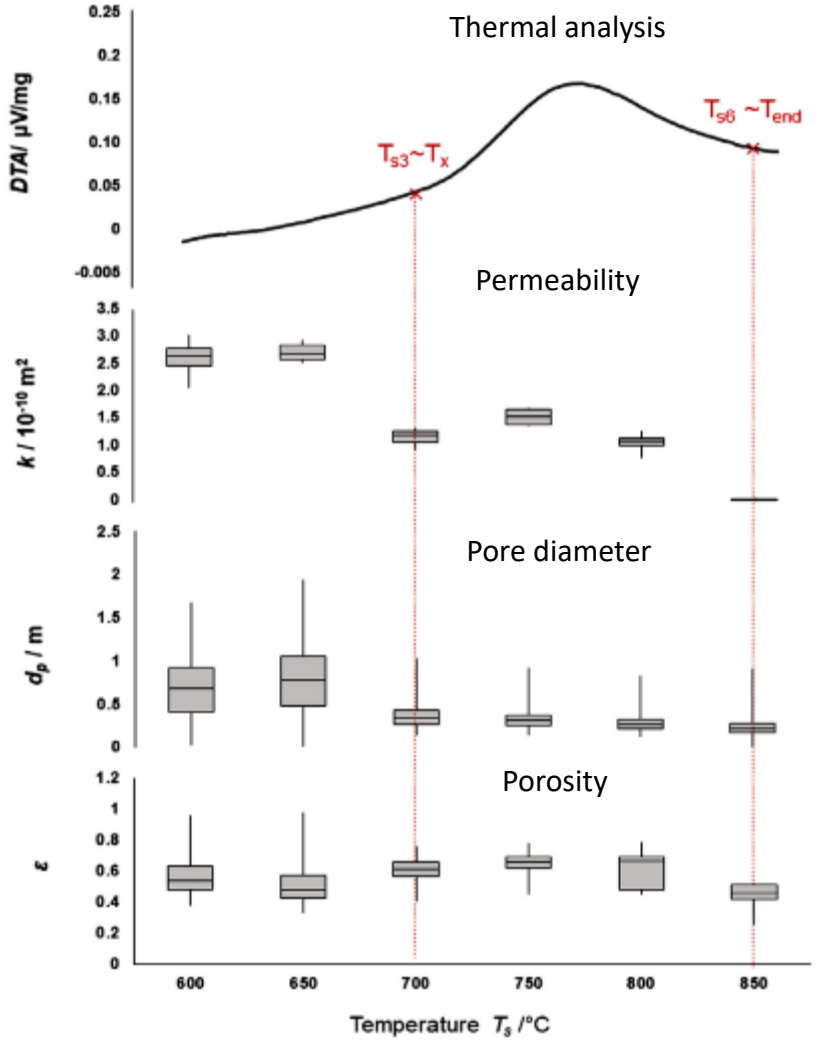




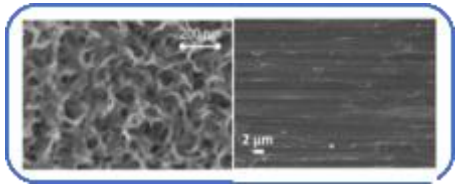
Micro-CT reconstruction



Controllable properties (pore characteristics, mechanical strength…) depending on glass composition, fabrication method, sintering etc.



Ti modifications for hard and soft tissue regeneration



HARD TISSUE

Application: dental implants, orthopaedic implants.

Problem to be solved:

- Low osseointegration of titanium implants in case of low quality bone,
- Excessive inflammatory response
- Biofilm formation

Strategy:

Micro+Nano textured (Figure C) and highly hydroxylated (Figure D) Ti surface capable of:

- Increasing osteoblasts differentiation (Figure E)
- Reducing macrophages adhesion and proliferation (Figure F)
- Reducing bacteria adhesion (Figure G)

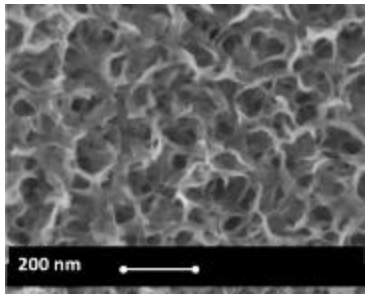


FIGURE C

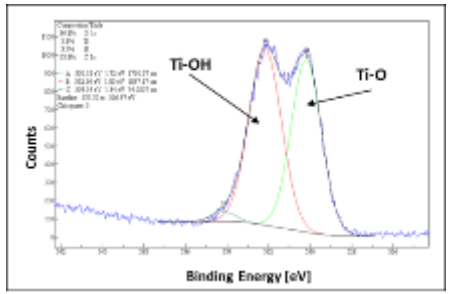


FIGURE D

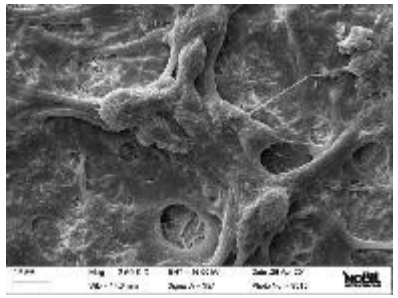


FIGURE E

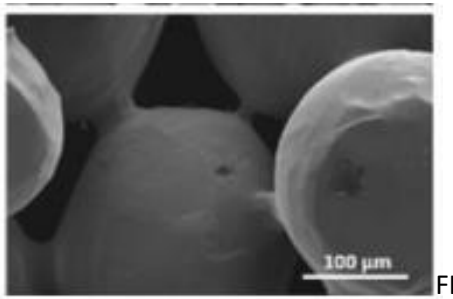


FIGURE F

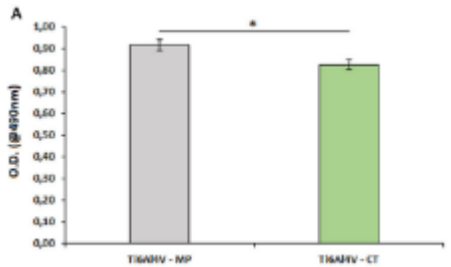
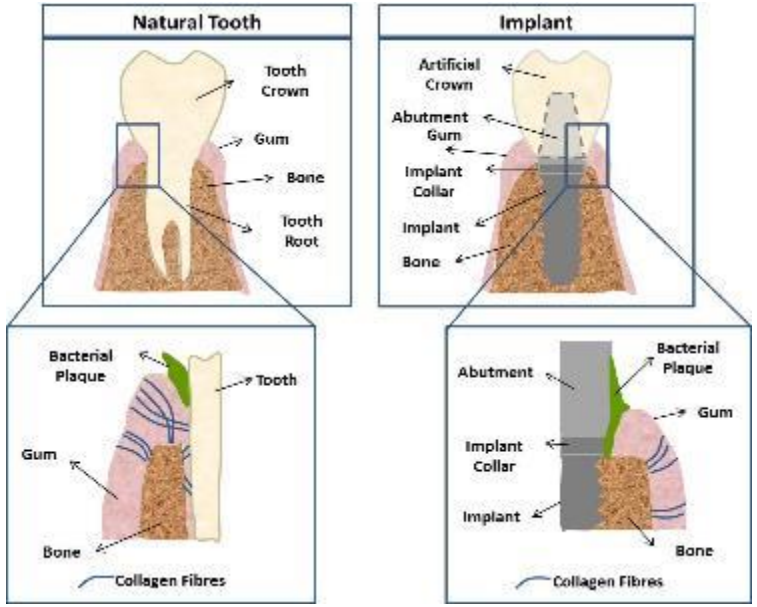


FIGURE G

SOFT TISSUES

Application: transmucosal dental implants, percutaneous orthopaedic implants.



Problems to be solved:

- peri-implant mucositis,
- periimplantitis,
- epithelial downgrowth.

Strategy: surface capable of

- promoting the oriented growth of soft tissues (gum sealing) (FIGURE A)
- limiting growth of these tissues at the level of the collar,
- limiting the adhesion of bacteria
- if necessary, active antibacterial action (FIGURE B)

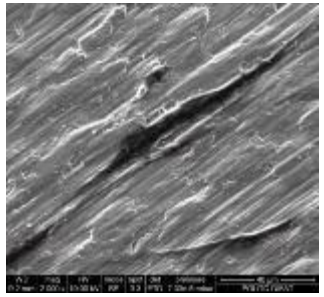


FIGURE A

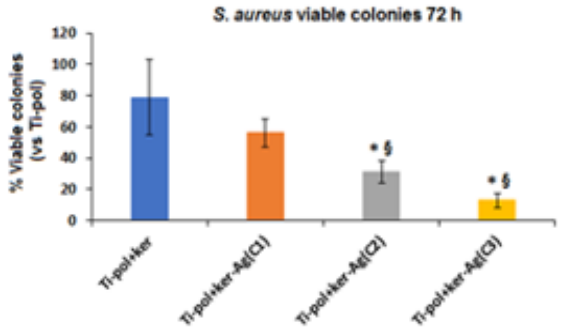
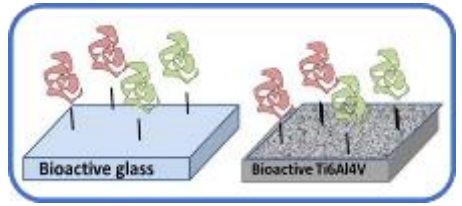
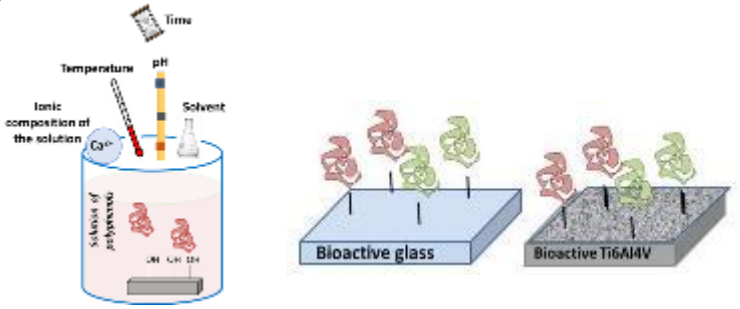


FIGURE B

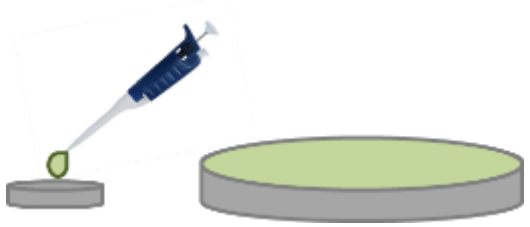
Surface functionalization & coating

Extraction of active molecules (e.g. polyphenols, cheratin) from natural products/byproducts



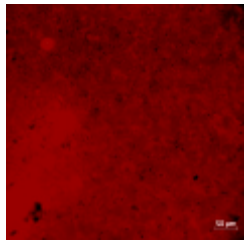


Surface **FUNCTIONALIZATION**: Soaking of the materials in a proper solution of polyphenols. The solution is optimized depending on the material

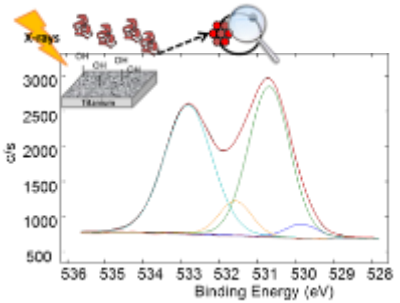


Surface **COATING**: deposition of a continuous (and thick) layer of the biomolecule from its solution.

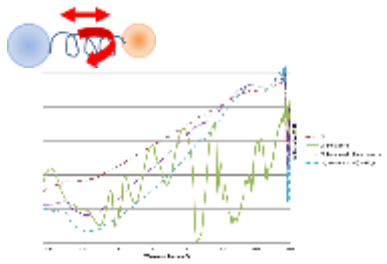
Consolidated protocol for SURFACE CHARACTERIZATION of functionalized/coated surfaces



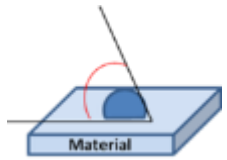
Fluorescence microscopy: molecular presence and distribution



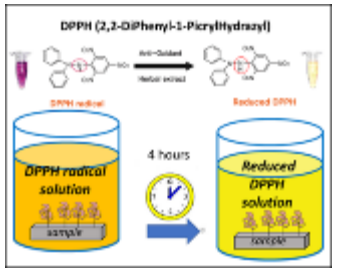
XPS: chemical composition and functional groups



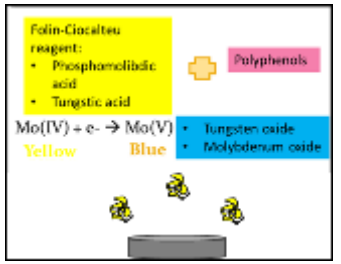
FTIR: chemical composition and functional groups



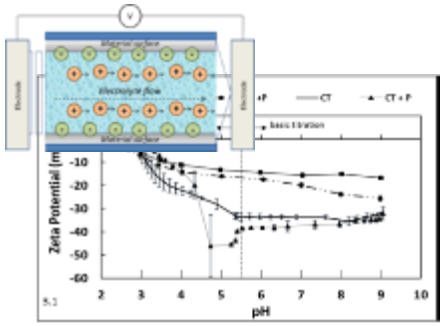
Contact angle: surface wettability



DPPH: radical scavenging activity

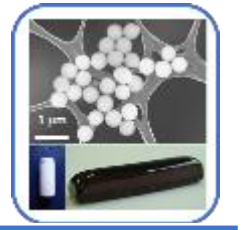


F&C: redox activity



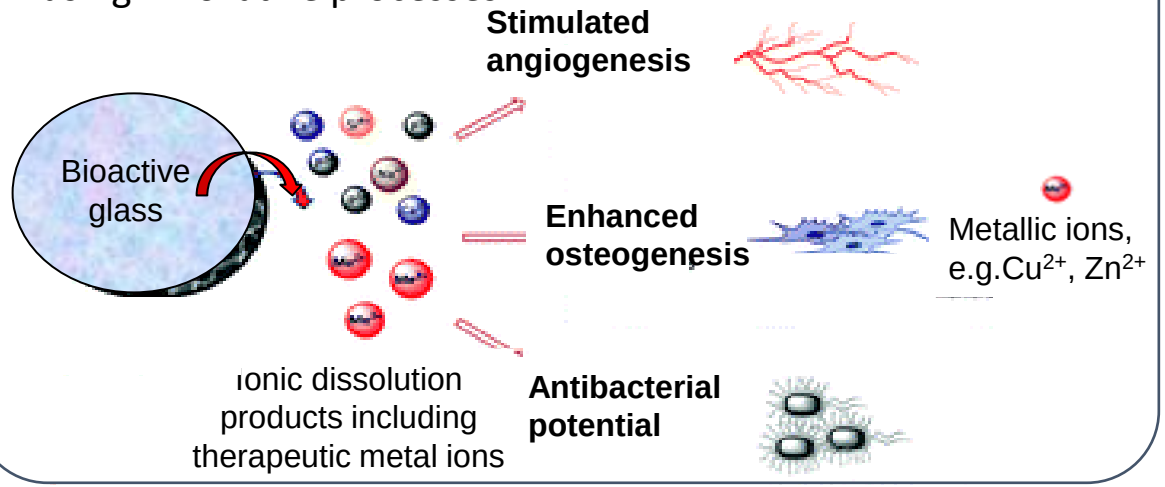
Zeta potential: surface charge, functional groups and stability

Tailored bioactive glasses for hard and soft tissue regeneration



Aim of the research:

To design multifunctional glasses with tailored composition by doping bioactive glass (synthesized by sol-gel or melt and quenching process) with well-known therapeutic ions able to stimulate different biological effects or exploring new ones, using innovative processes.



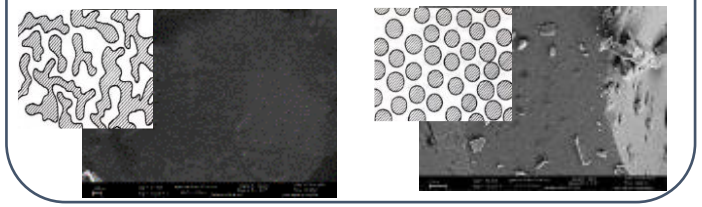
Element	Form	Biological activity
Ag	Powders, bulk, scaffold, coatings	Antibacterial
Mn	Powders, bulk, scaffold	Stimulates the metabolism of muscle and bone
Sr	Powders, bulk, scaffold	Anti-resorption effect on bone
B	Powders, bulk	Stimulates wound healing, improves bone health.
Zn	Powders, bulk	Bone formation promotion
Cu	Powders, bulk	Stimulates angiogenesis
Te	Powders, bulk	Antibacterial, antioxidant
Li	Powders, scaffold	Stimulates periodontal repair
Co	Powders	Stimulates angiogenesis

Form of bioactive glasses:

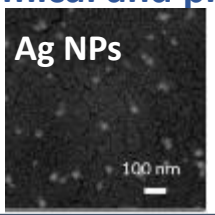
- Bulk
- Micro/nanopowders → Composites
- Coatings
- Scaffold

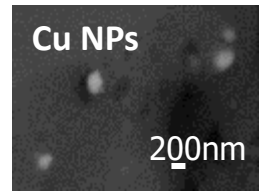
Nanostructured glasses → glass decomposition

Spinodal Dropet-like

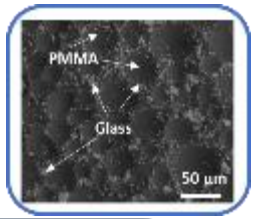


In-situ reduction of antibacterial metallic nanoparticles by chemical and physical processes





Multifunctional composite bone cements

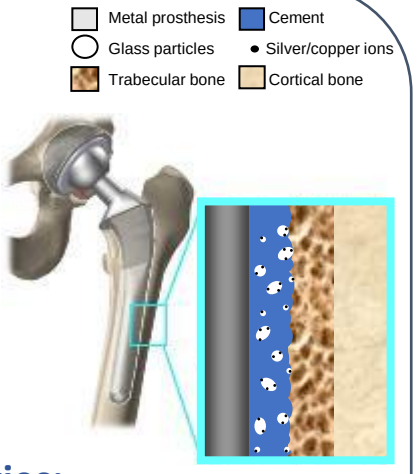


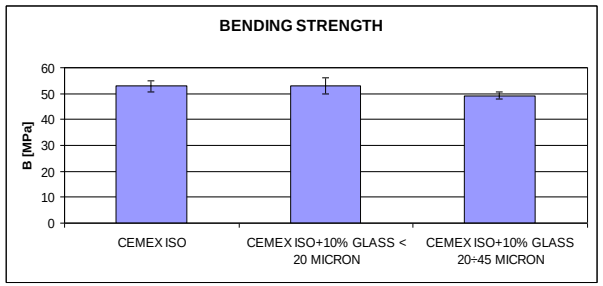
Antibacterial Bone cements

Aim of the research:

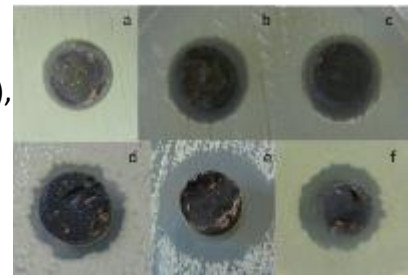
Innovative multifunctional composite PMMA-based bone cement for orthopaedic prostheses fixation, for temporary prostheses realization and eventually for spinal surgery both **BIOACTIVE and ANTIBACTERIAL**.

ONE inorganic phase added to PMMA: a BIOACTIVE GLASS or glass-ceramic containing metallic ions with ANTIBACTERIAL effect





Antibacterial test:
S. aureus (a-c), Bacillus (d), E. coli (e) and C. albicans (f)



Properties:

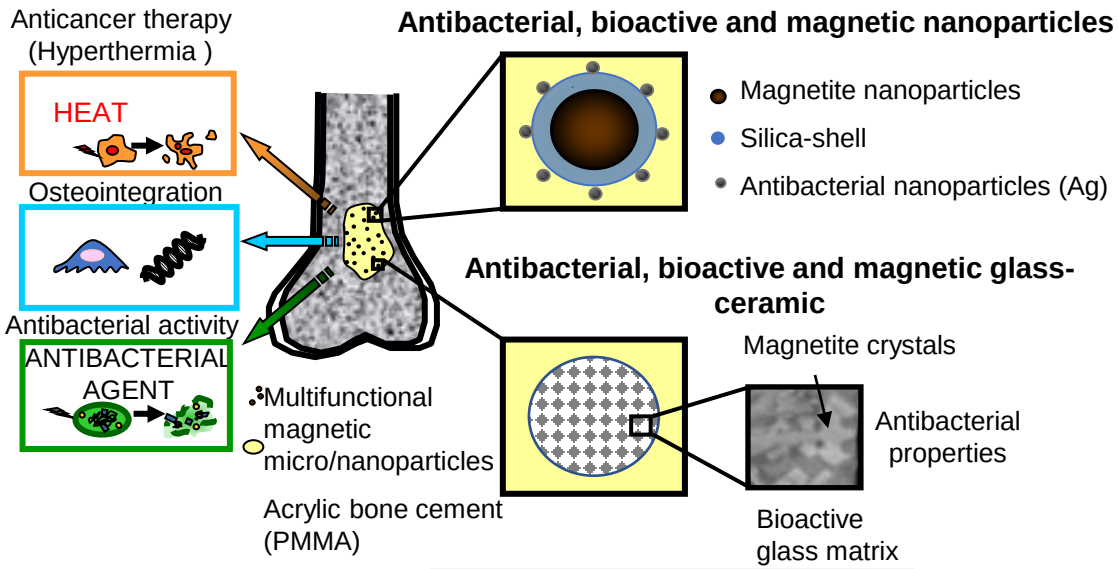
- Prolonged release of silver/copper ions Release
- Kinetics modulated according to the glass composition
- Maintenance of the mechanical properties of the original cement.
- Reduction of the local temperature increase.
- Antimicrobial action on all bacterial and fungal strains, limited development of resistance

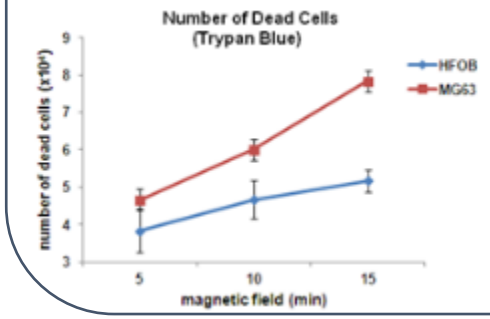
Ferrimagnetic bone cements

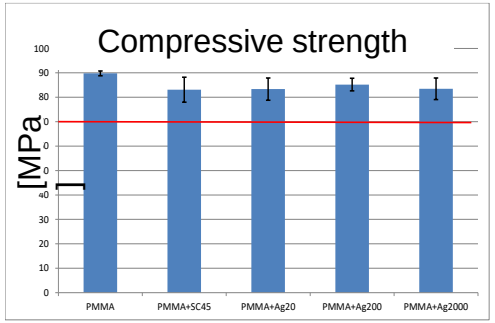
Aim of the research:

Designs of an multifunctional PMMA-based cement for tumor treatment by introducing:

- a **ferrimagnetic, bioactive and antibacterial** glass-ceramic
- **superparamagnetic and bioactive/antibacterial** NPs

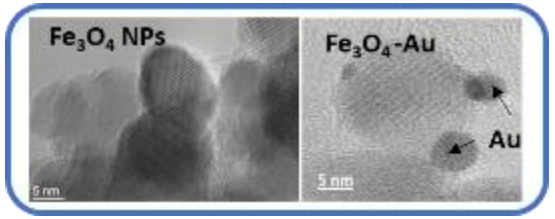




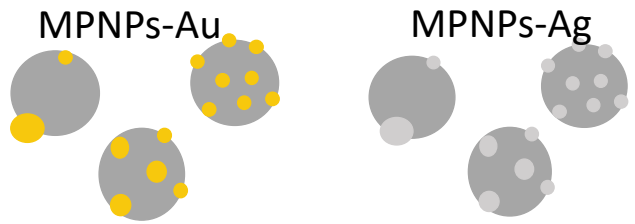


Antibacterial test

Magnetic-plasmonic NPs for tumor theranostics - gene therapy

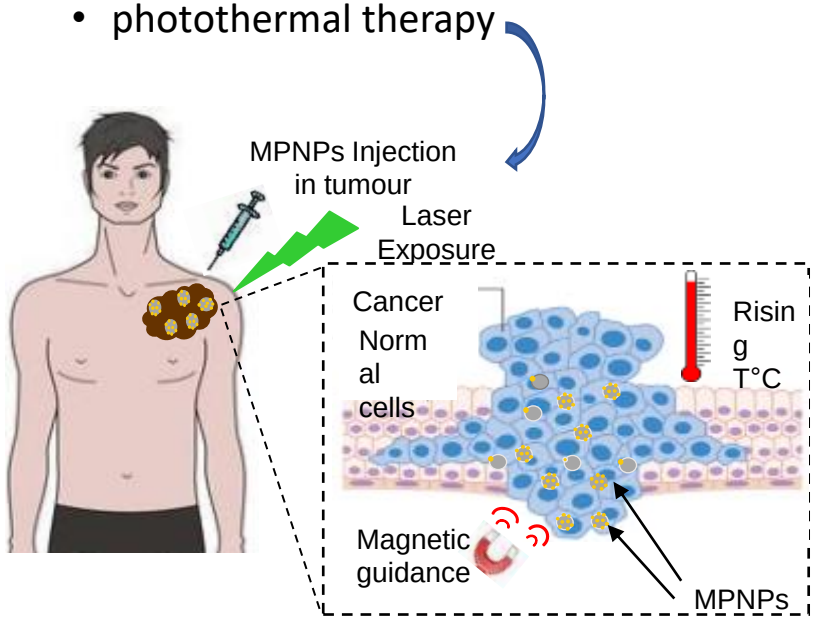


Aim of the research:
to develop hybrid magneto-plasminic nanoplatforms (MPNPs) for theranostic/gene therapy composed of a magnetic core (Iron Oxide nanoparticles - SPIONs) and an external AuNPs/AgNPs decoration acting in synergy to combine magnetic and plasmonic properties.



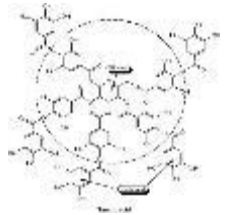
Properties:

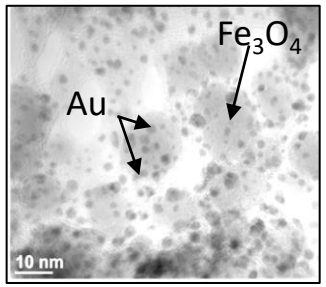
- directly reach the tumor site
- drug delivery
- contrast agent for MRI
- photothermal therapy



Strategy: to prepare the NPs with **eco-friendly agent** able to reduce and stabilize MPNPS with a GREEN-SYNTHESIS METHOD.

Tannic acid





Curcumin

MPNPs characterization: magnetic behaviour(a), UV-Vis (b), FT-IR (c), Laser exposure (d)