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Unleashing the antibacterial and antibiofilm potential of silica-based nanomaterials functionalized with an organotin(IV) compound

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General condition on the synthesis and characterization of the materials

Some reagents such as tetraethyl orthosilicate (TEOS), 3-(aminopropyl)triethoxysilane (AP), triphenyltin chloride, N-(3-Dimethylaminopropyl)-N′-ethylcarbodiimide hydrochloride (EDAC), N-Hydroxysuccinimide (NHS), Cetylpyridinium bromide hydrate (CPB), Urea 99%, Pluronic 123, triphenyltin(IV) chloride and (N-morpholino) ethanesulfonic acid (MES), were purchased from Sigma Aldrich. The hexadecyltrimethylammonium bromide (CTAB) and 3-mercaptopropyltriethoxysilane (MP) were purchased in Acros Organics and Fluorochem, respectively. 3-Carboxypropyl)triphenylphosphonium bromide (PPh_3^+) was purchased in Apollo scientific. Resazurin and MTT reagents used for the biological assays were purchased from VWR and Biotium respectively.

To perform the N_2 absorption-desorption isotherms (BET) were measured with the Micromeritics ASAP 2020 porosimeter. Transmission electron microscopy (TEM) images were obtained on a JEOL JEM 1010, operating at 100 kV. FT-IR vibrational band spectra, KBr pellets were used with the material inside, and were measured in Spectrum two™ 6700 FT-IR spectrophotometer (Perkin Elmer). Solid-state UV-vis measurements were carried out with Perkin Elmer LAMBDA 850+ UV/Vis Spectrophotometer. For X-ray diffraction (XRD) measurement, Philips diffractometer model PW3040/00 X'Pert MPD/MRD at 45 kV 40 mA was used, using a Cu Kα wavelength (λ = 1.5418 Å) 380 FT-IR with a Michelson filter interferometer. Mass losses were measured between 30 and 800 °C by thermogravimetry (TG) using a 20 °C/min ramp and 50 A nitrogen intensity with a DSC/TGA Discovery SDT650. Measurements for metal determination by ICP were made with the Varian Vista AX Pro (λ_{Sn} = 235.485 nm) equipment.

The equipment used in the tests carried out to check the bacterial activity of the materials are as follows Biotek Synergy HT Microplate Reader and SP-2000UV Spectrophotometer.

All reactions carried out under inert atmosphere and dry nitrogen are performed inside standard Schlenk tubes and the solvents used in this type of reaction were distilled from the appropriate drying agents and degassed before use.

Scanning Electron Microscope (SEM)

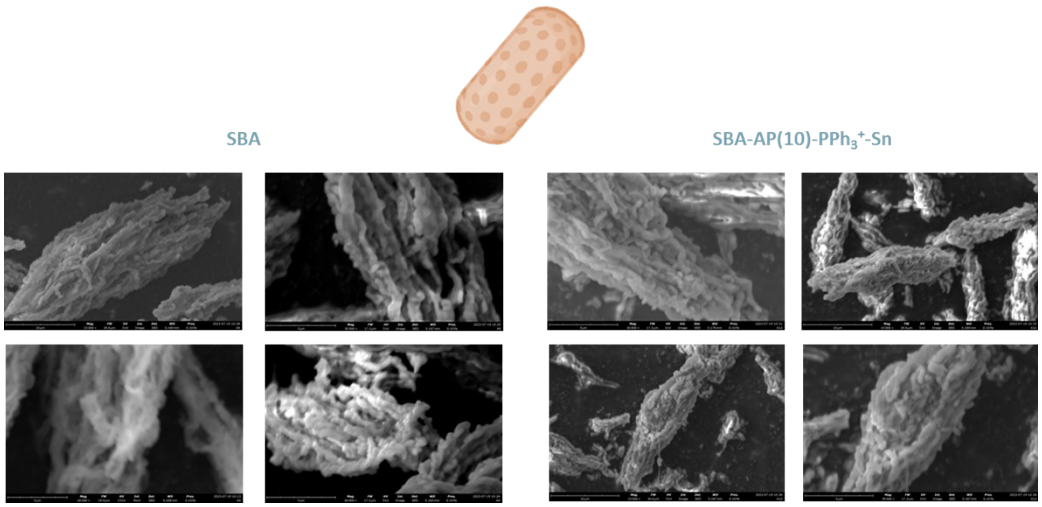


Figure S1. Images obtained by SEM from **SBA** and **SBA- AP(10)-PPh_3^+-Sn**.

Infrared spectrum (FT-IR)

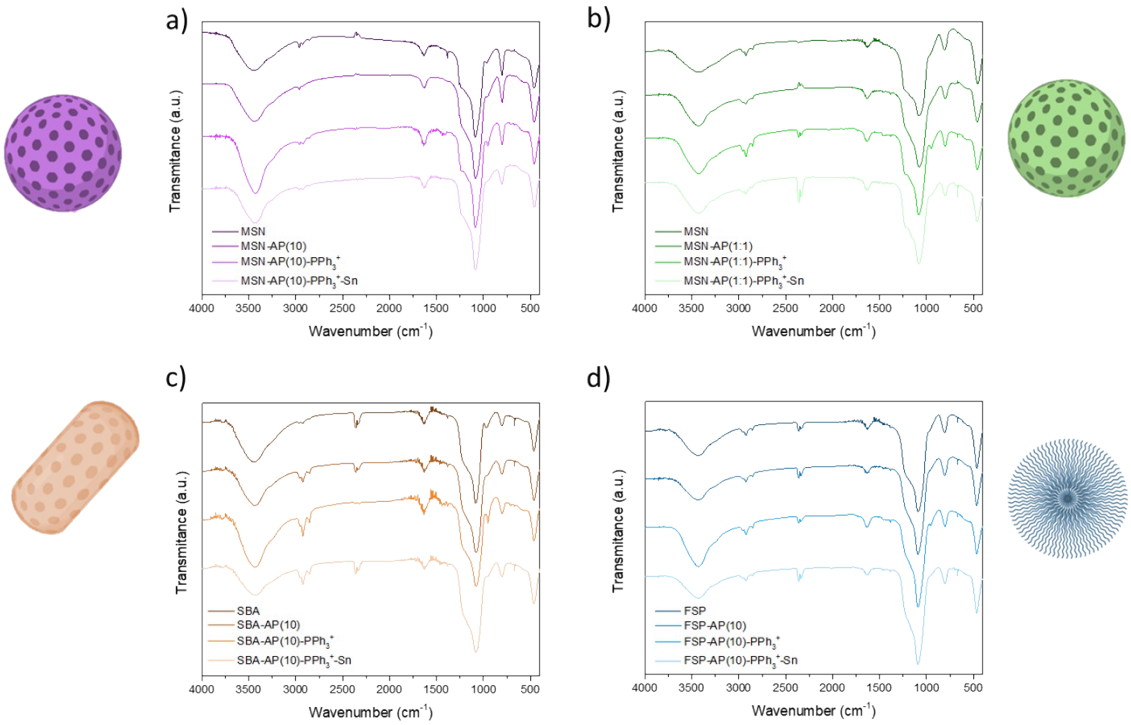


Figure S2. FT-IR spectra obtained for all materials: (a) **MSN** with AP(10); (b) **MSN** with AP(1:1); (c) **SBA**; (d) **FSP**.

Ultraviolet Visible Spectroscopy (UV-Vis)

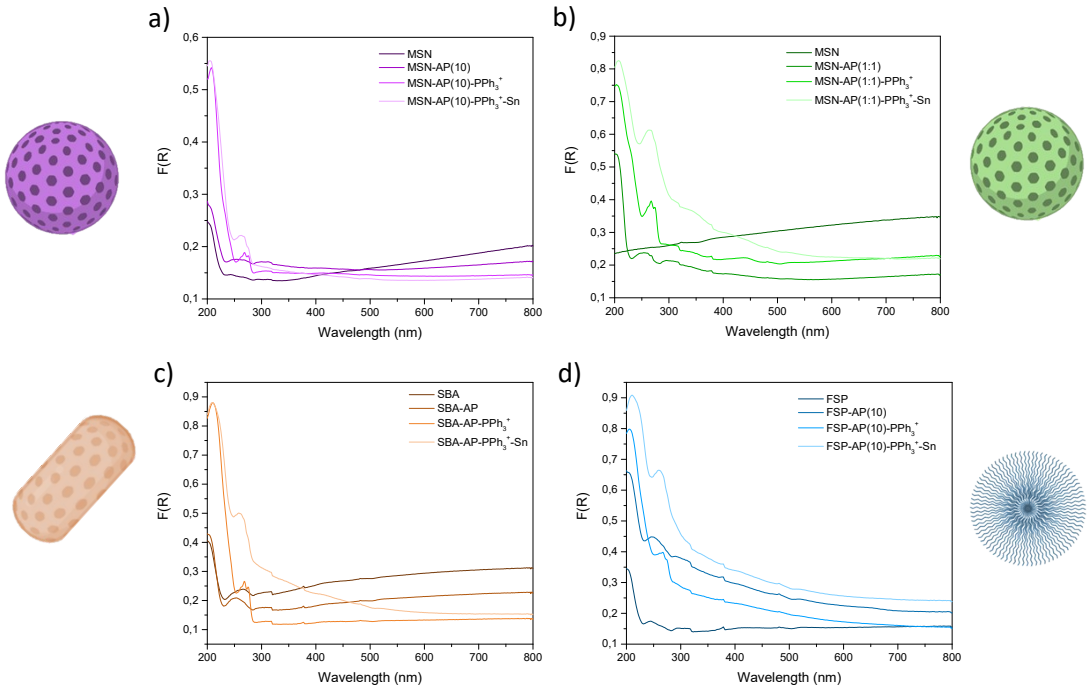


Figure S3. UV-Vis spectra obtained for all materials: (a) **MSN** with AP(10); (b) **MSN** with AP(1:1); (c) **SBA**; (d) **FSP**.

Thermogravimetric (TG)

Figure S4. TG spectra obtained of: **MSN-AP(10)**, **MSN-AP(1:1)**, **SBA-AP(10)** and **FSP-AP(10)**.

Minimum Inhibitory Concentration (MIC)

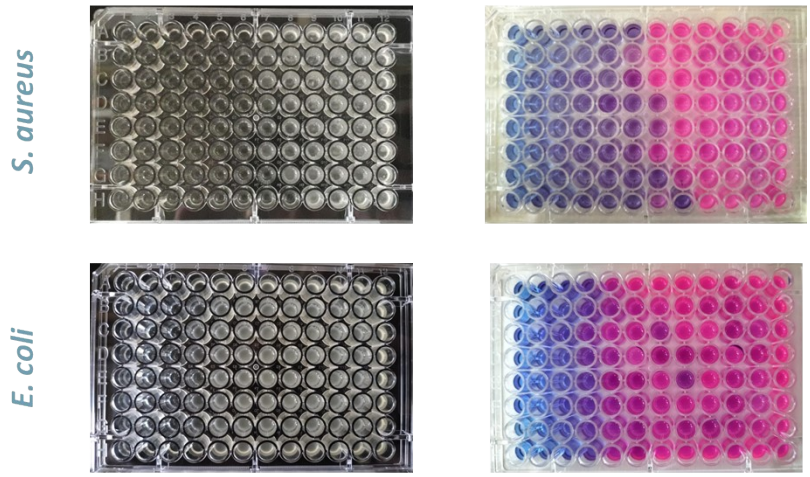
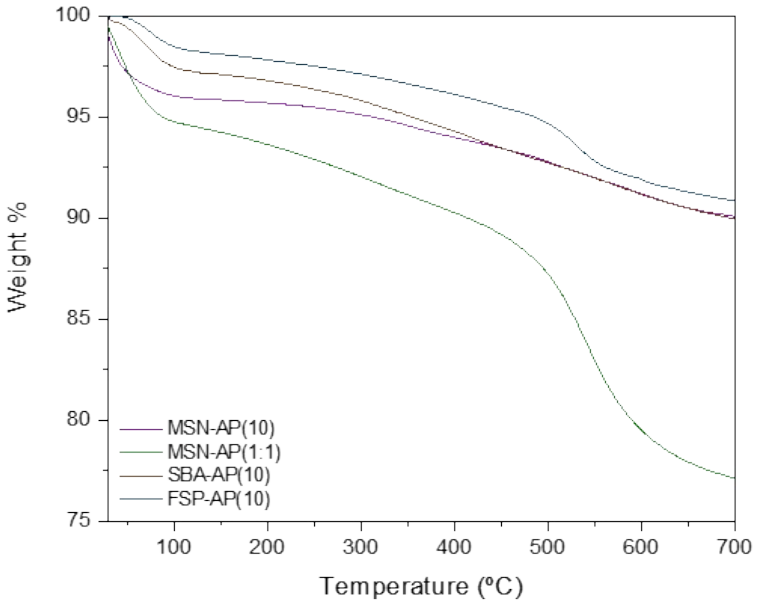


Figure S5. MIC assay plates: (a) after incubation; (b) after addition of Resazurin.

Oxidative stress (ROS)



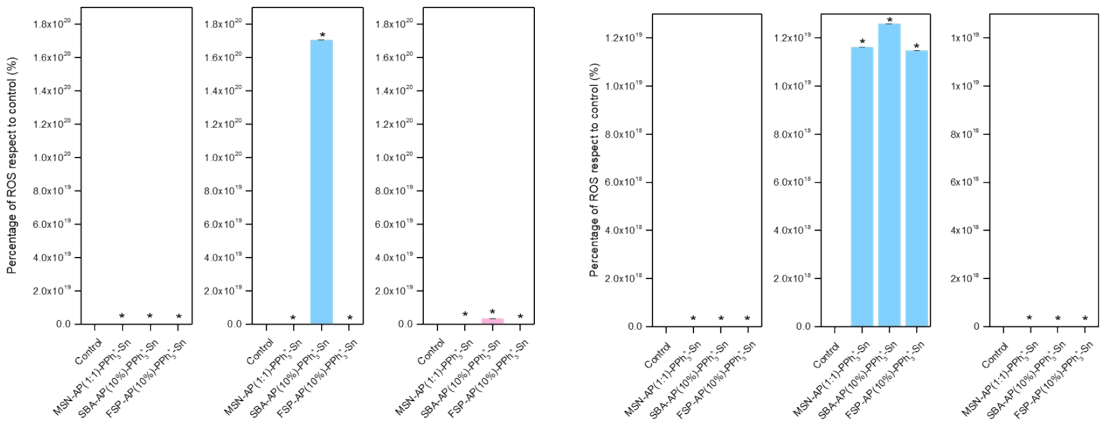
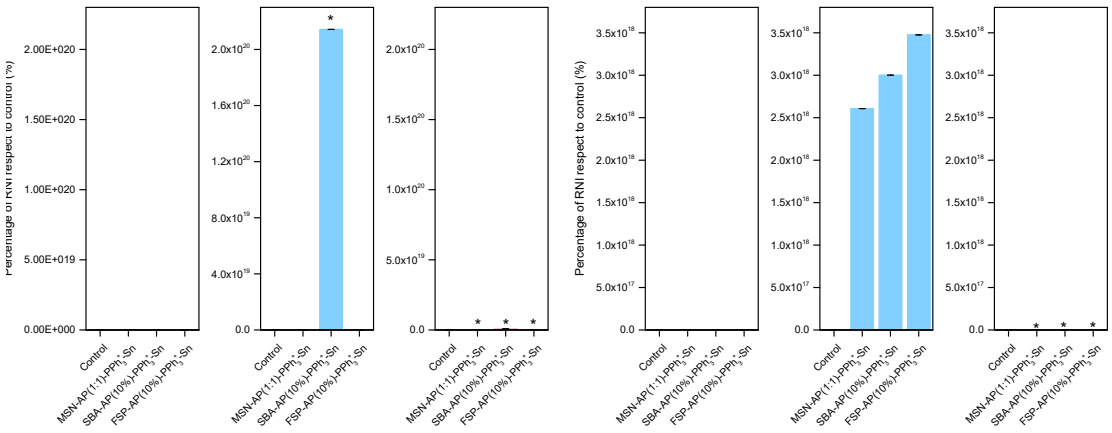


Figure S6. Percentages of ROS obtained after incubation with the materials in bacteria: (a) *S. aureus* 1 h; (b) *S. aureus* 4 h*; (c) S. aureus* 24 h; (d) *E. coli* 1 h; (e) *E. coli* 4 h; (f) *E. coli* 24 h (*= p < 0.05).



Nitrosative stress (RNI)

Figure S7. Percentages of RNI obtained after incubation with the materials in the strains: (a) *S. aureus* 1 h; (b) *S. aureus* 4 h*; (c) S. aureus* 24 h; (d) *E. coli* 1 h; (e) *E. coli* 4 h; (f) *E. coli* 24 h (*= p < 0.05).

Oxidative stress determined using glutathione

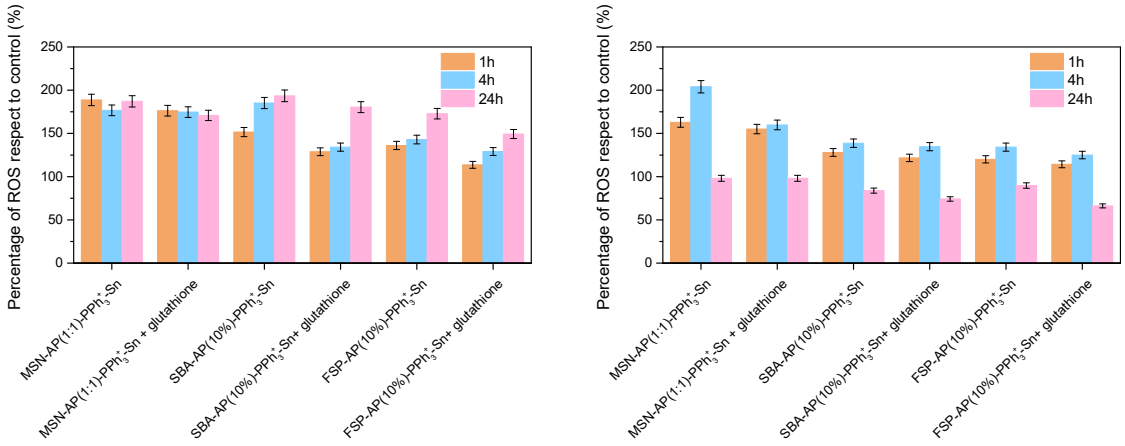


Figure S8. Percentages of Ros with glutathione obtained after incubation with the materials in the strains: (a) *S. aureus* 1 h; (b) *S. aureus* 4 h*; (c) S. aureus* 24 h; (d) *E. coli* 1 h; (e) *E. coli* 4 h; (f) *E. coli* 24 h (*= $p < 0.05$).

MTT Assay

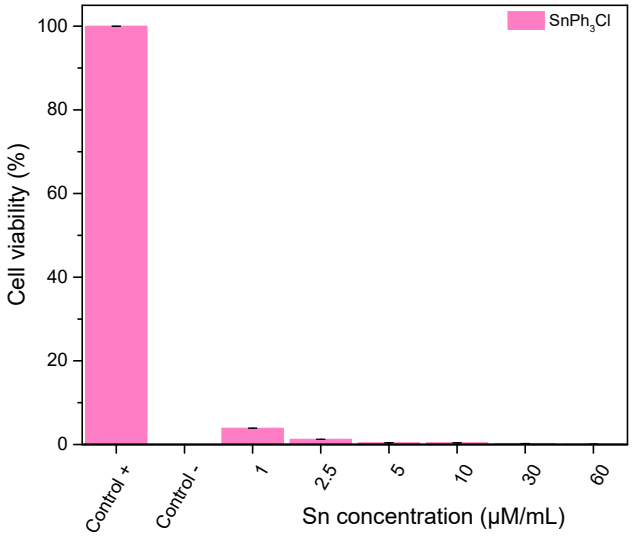


Figure S9. Cell viability results produced by the $SnPh_3Cl$ compound against the healthy cell line Hek 293T in the MTT assay. Results are expressed as % of control (mean ± SD, n = 3 replicates/experiment).

Resazurin Assay

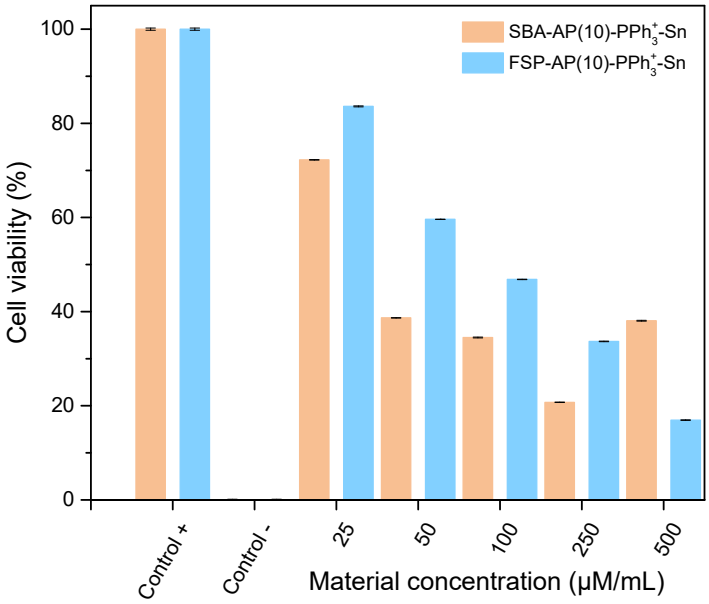


Figure S10. Cell viability results produced by the final materials against the healthy cell line Hek 293T in the Resazurin assay. Results are expressed as % of control (mean ± SD, n = 3 replicates/experiment).