MAPLE ANTIMICROBIAL COATINGS BASED ON LOW-COST SUSTAINABLE NATURAL RESOURCES

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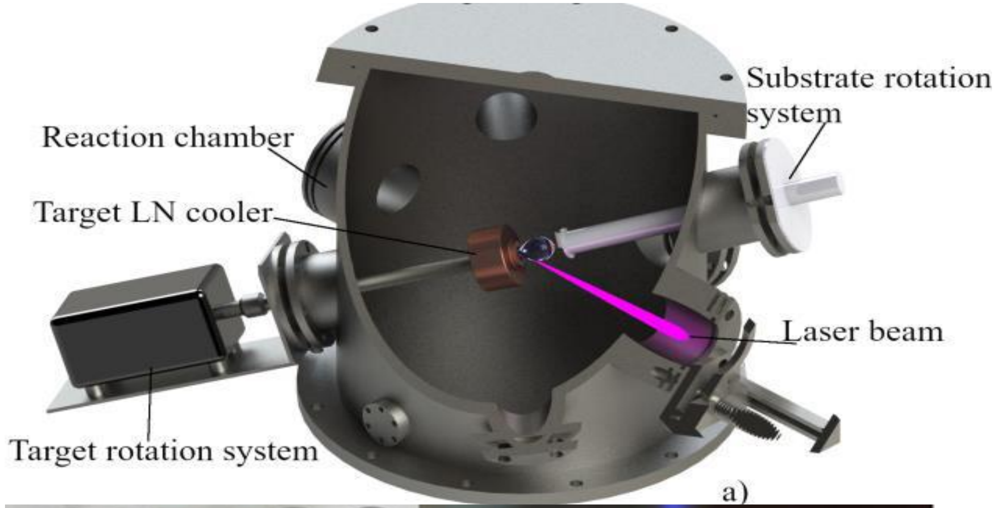
MAIN OBJECTIVES :

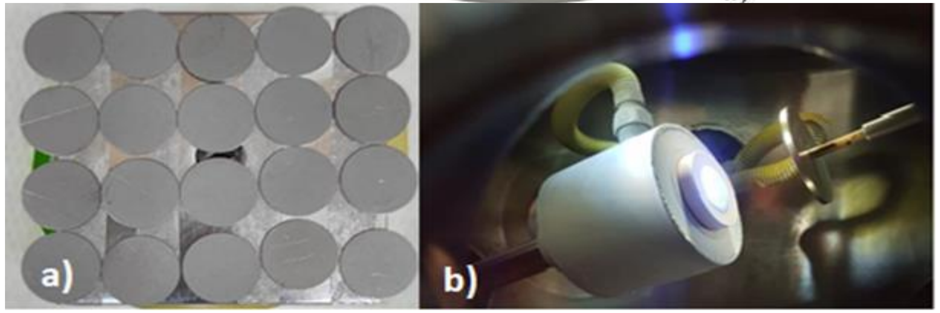
O1. MAPLE-deposition of functionalized coatings onto different substrates by pulsed excimer laser.

O2. Physicochemical, microstructural and morphological characterization of functionalized surfaces by complementary investigations techniques.

O3. *In vitro* assessment of the biological performances of the obtained coatings, in term of **biocompatibility** and **antimicrobial activity** (against Gram-positive and Gram–negative bacteria (*S. mutans*, *S. aureus*, *P. aeruginosa*, *E. coli*, *E. faecalis*, *P. anaerobius*) and fungal strains (*C. albicans*)).

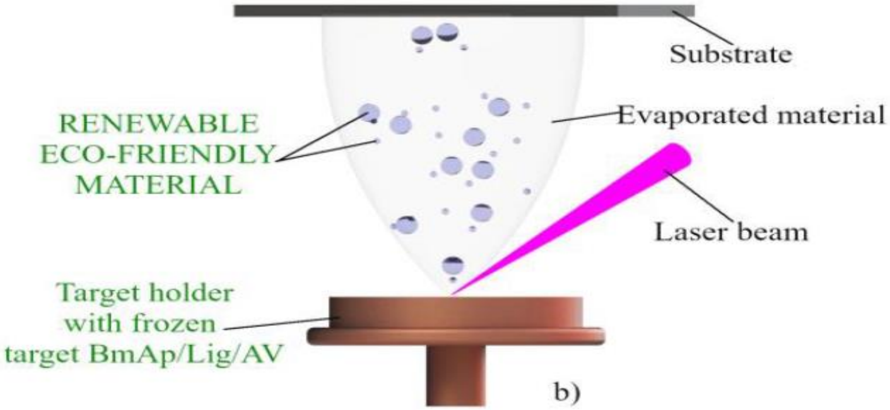
(a) MAPLE experimental system





Images (a) of the arrangement of the substrates to be deposited, and (b) of the frozen HA-Lig-AV target prepared.

(b) MAPLE deposition scheme.



Experimental Conditions:

KrF* laser source: λ= 248 nm, $\tau_{FWHM} \leq$ 25 n, Vacuum 10-2 mbar, laser fluency : 350 mJ/cm^2 .

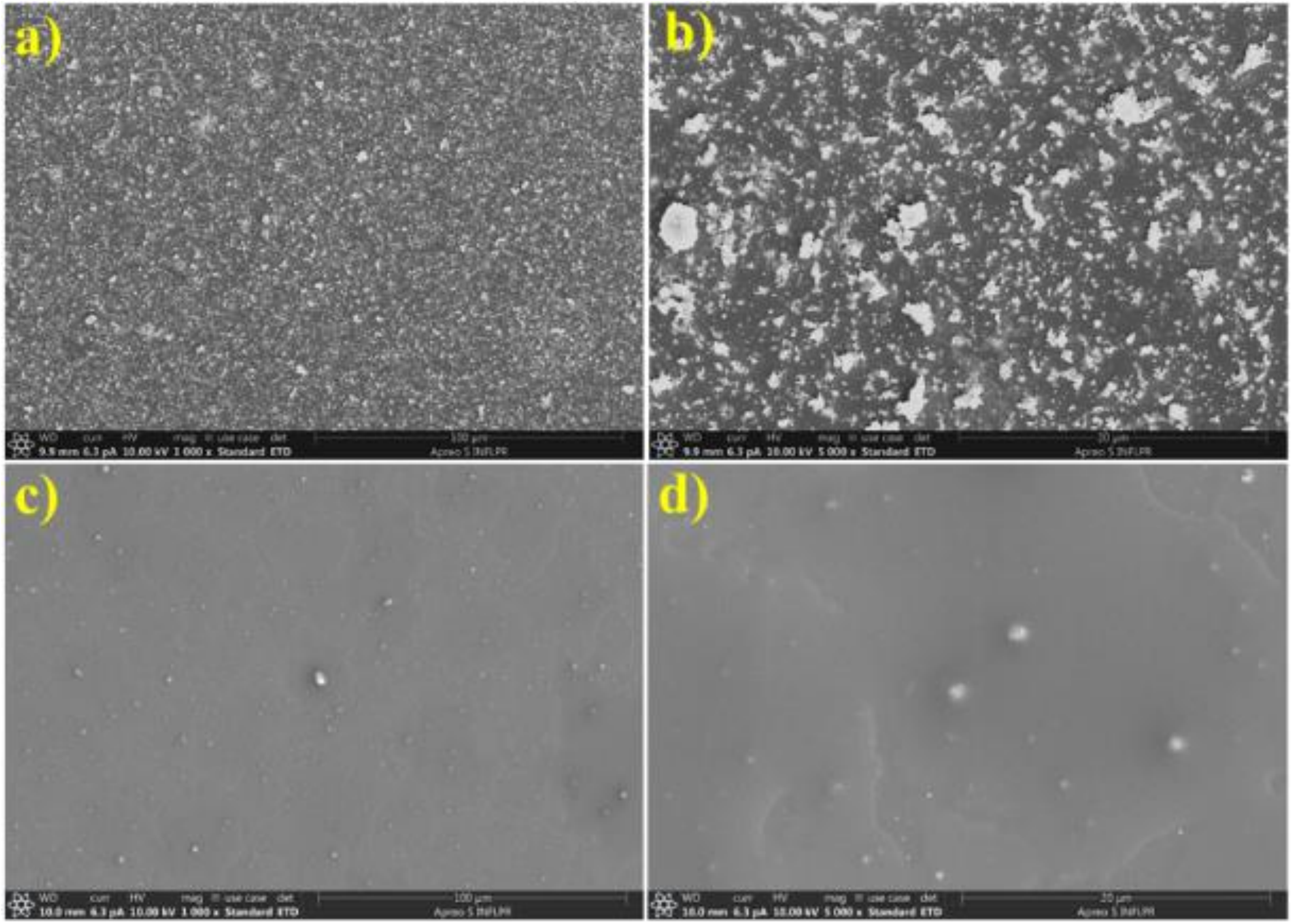
SAMPLE CODE	OBSERVATIONS
HA-Lig	((HA-Lig), c = 5% in DMSO)
HA-Lig-AV-recipe 1	((HA-Lig-AV-recipe 1; Lig: AV -1: 3), c = 5% in DMSO)
HA-Lig-AV-recipe 2	((HA-Lig-AV-recipe 2; Lig: AV -2: 2), c = 5% in DMSO)
HA-Lig-AV-recipe 3	((HA-Lig-AV-recipe 3; Lig: AV -3: 1), c = 5% in DMSO)

„Pull-out”Measurements

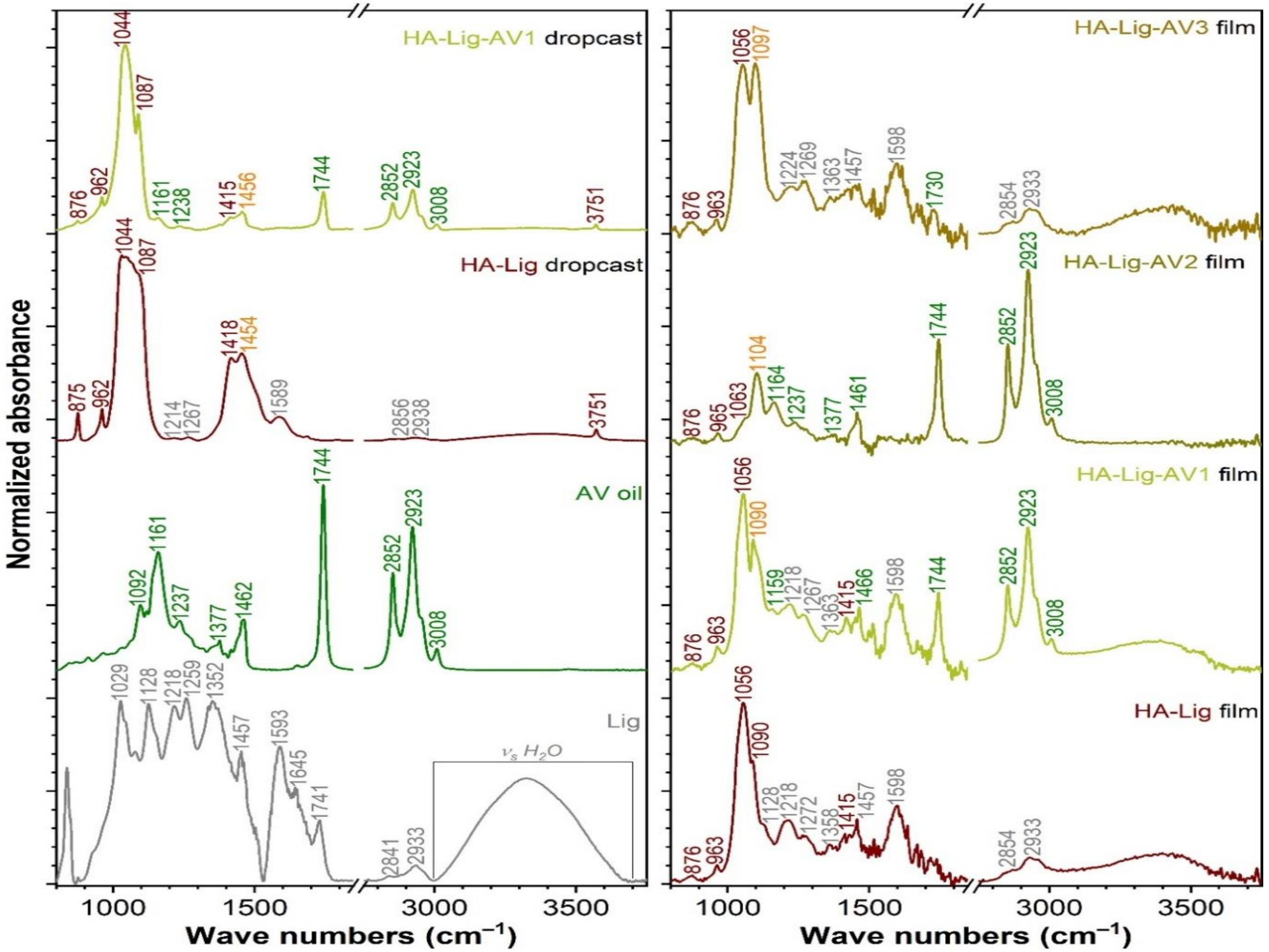
Sample Code	Adherence average values ±SD (MPa)
HA-Lig-AV-recipe 1	19.5±4
HA-Lig-AV-recipe 2	29 ±0.5
HA-Lig-AV-recipe 3	28±0.5

- Values close to, or even higher than, the minimum of 15 MPa, imposed by the international standard ISO (ISO 13779-2 / 2008) which regulates the manufacture of implant coatings for biomedical applications at high mechanical loads !

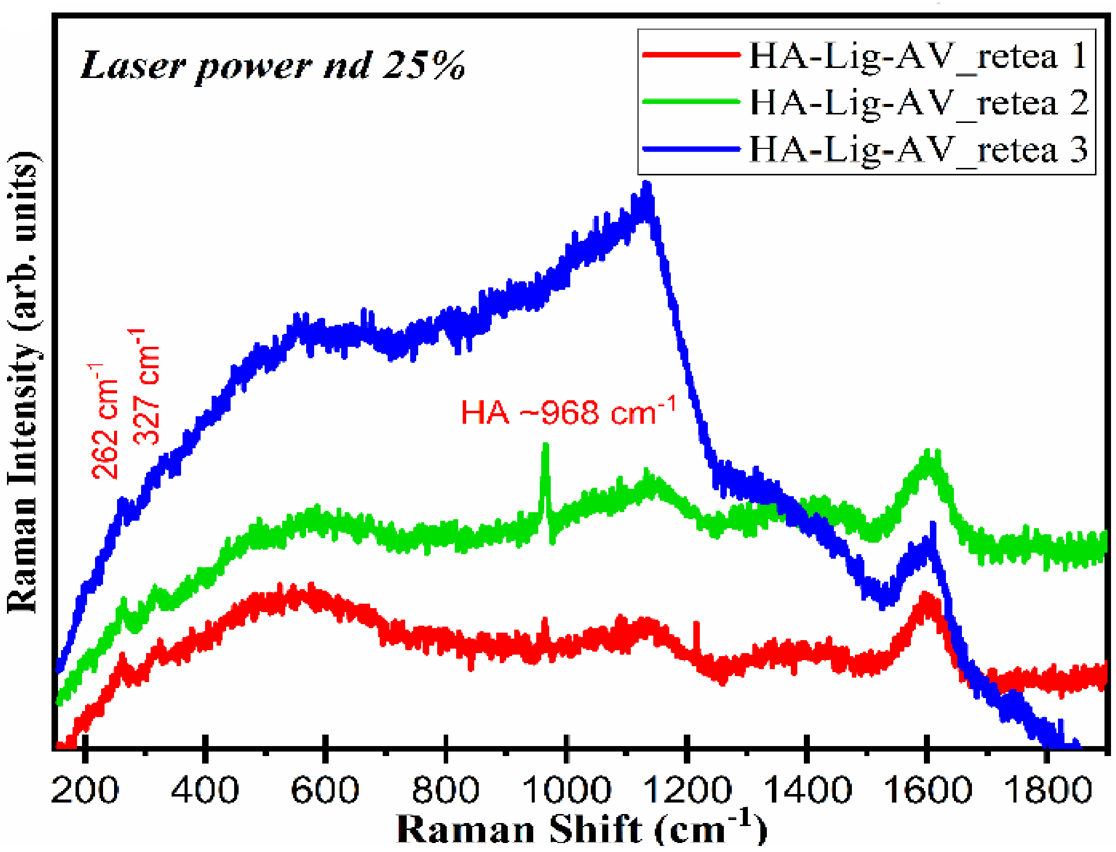
- The introduction of essential oil seems to influence the general morphology, so the size and diameters of the particles dispersed in the film matrix seem to fade as the concentration of aloe vera in the thin films of MAPLE increases.



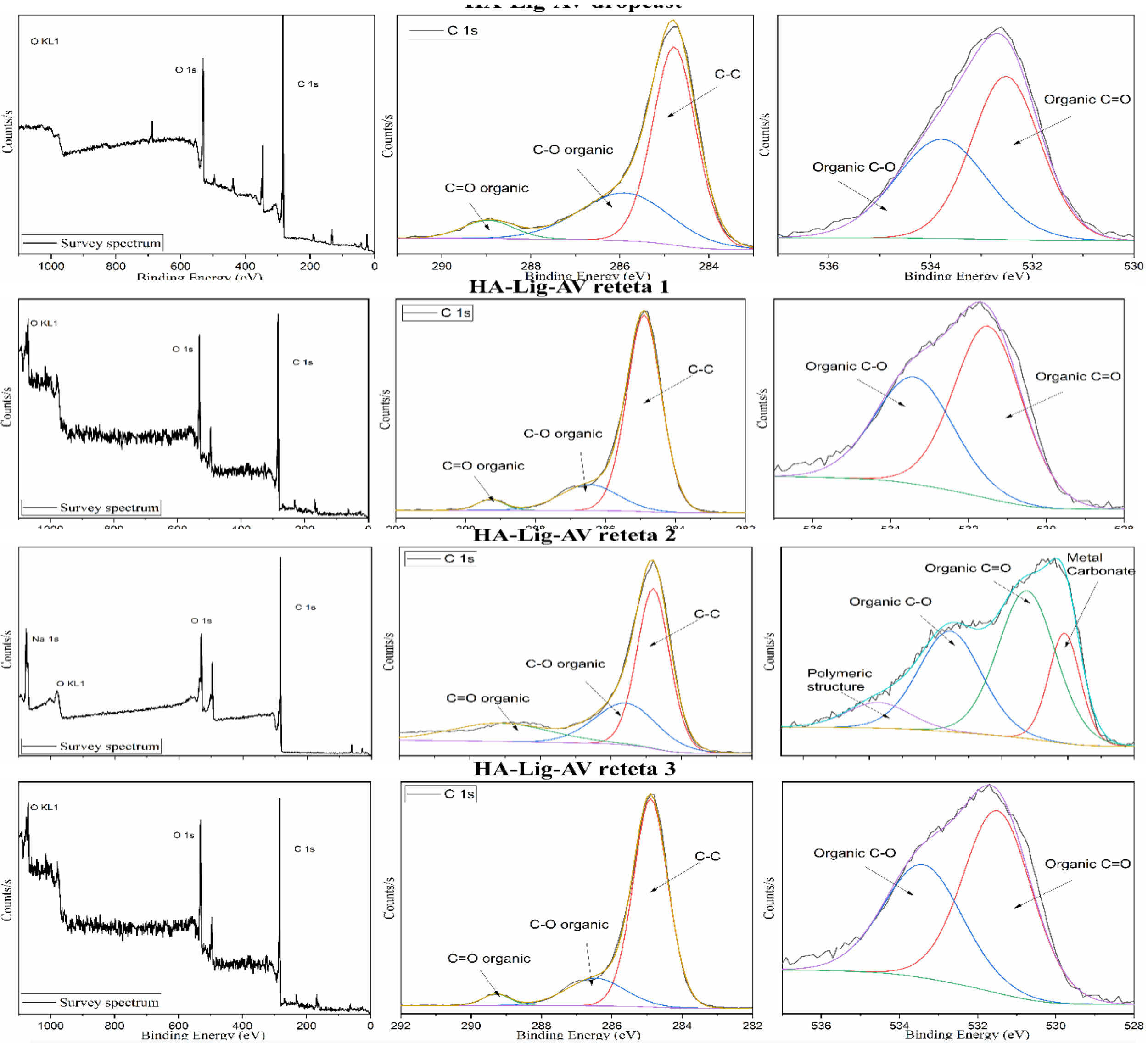
Typical SEM micrographs of HA-Lig thin films - 1000x magnification of (a); HA-Lig-magnification 5000x (b); HA-Lig -AV - magnification 1000x (c) and HA-Lig -AV - magnification 5000x (d) obtained by MAPLE technique



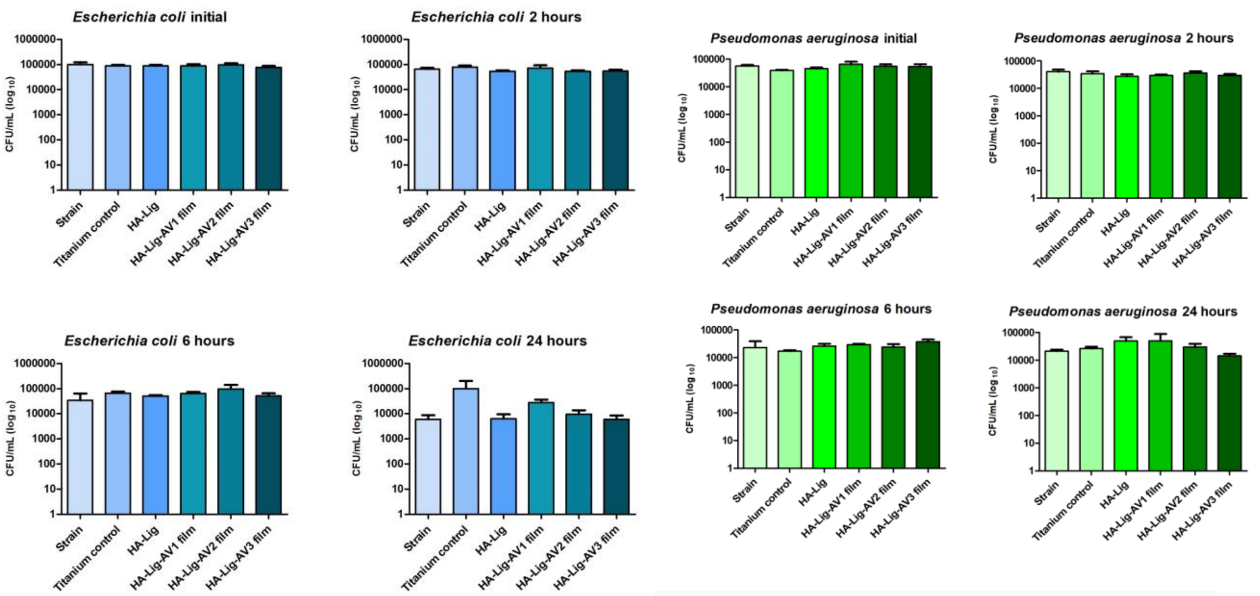
FTIR spectra of the investigated materials: Lignin powder; Aloe Vera essential oil, HA-Lig (dropcast and thin film); composite films: HA-Lig-AV1 (dropcast and thin film); HA-Lig-AV2 thin film; HA-Lig-AV3 thin film.

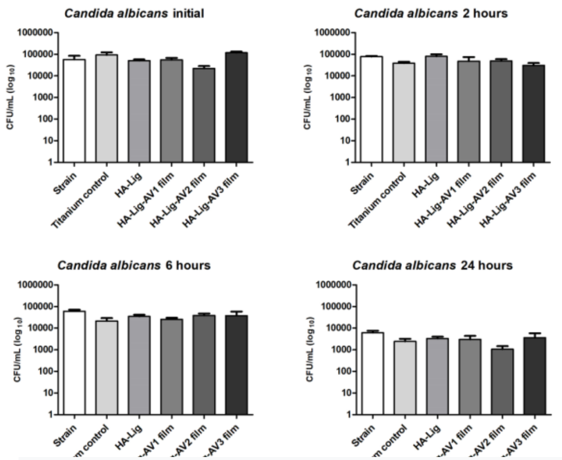


Raman spectra recorded at 25% laser power on the thin films: (HA-Lig-AV recipe 1; HA-Lig-AV recipe 2 and HA-Lig-AV recipe 3) synthesized by the MAPLE method recorded in the spectral region corresponding to the bands (1800-200) cm^{-1}



High-resolution XPS spectra of HA-Lig thin films; HA-Lig-AV-dropcast; HA-Lig-AV recipe 1; HA-Lig-AV recipe 2; HA-Lig-AV recipe3.





Evaluation of the dynamics of *Escherichia coli*, *Pseudomonas aeruginosa* and *Candida albicans* viability in the presence of tested materials

After 24 h:
Escherichia coli: HA-Lig-AV2;
Pseudomonas aeruginosa :HA-Lig-AV3;
Candida albicans: HA-Lig-AV2.

- Apatite-lignin-aloe vera (HA-Lig-AV) thin films were synthesized by a matrix-assisted pulsed laser evaporation technique using a KrF * excimer laser source ($\lambda = 248$ nm, $\tau_{FWHM} \leq 25$ ns).

- When the amount of essential oil is equal to that of organic material, a fine, uniform and relatively homogeneous distribution of the deposited material was obtained.

- X-ray photoelectron spectroscopy (XPS) revealed the presence of organic materials and the integrity of the chemical functions and the stoichiometry of the unaltered deposited material was demonstrated. Raman spectroscopy was in agreement with FTIR investigations and the molecular vibrations characteristic of the materials present in the structure of the films were highlighted.

- The viability of Gram-positive bacteria (*E. coli*) is affected by 24-hour contact with HA-Lig-AV2 film material. In the case of Gram-negative bacteria included in the study, HA-Lig-AV3 film inhibits microbial growth after 24 hours of contact. HA-Lig-AV2 film, after 24 hours, inhibits the development of *C. albicans* strain .

- Following the antimicrobial characterizations performed during this stage, we were able to identify the **optimal material recipe** (namely HA-Lig-AV2; Lig: AV ratio -2: 2)

Perspectives:

Natural antimicrobial agent release!(biodegradability)

(corrosion stability and bioactivity in biological simulated fluids)

Acknowledgments

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Thank you for your attention!