NBactSpace - Easily up-scalable and non-toxic coatings with antimicrobial broad spectrum activity for spacecraft indoors

ESA AO/1-9363/18/NL/KML

INVITATION TO TENDER FOR MATERIALS FOR ANTIMICROBIAL / ANTIFUNGAL SURFACE TREATMENT IN CONFINED INHABITED ENVIRONMENT IN HUMAN SPACEFLIGHT

FINAL REVIEW MEETING

26.01.2022

OUTLINE

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY

1) General description

2) Main outcomes

3) Feedback on comments on deliverables

I - General description

PROJECT INFORMATION

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- **Call : Tendering Conditions for Express Procurement Procedure" - EXPRO/TC**
- **Project start: 01/03/19**
- **Project duration: 34 months**
- **Type of project:**
  - [X] Competitive project
  - [ ] Collaborative project
  - [ ] Contract research or Service delivery project
  - [ ] Call for tenders (including ESA)
  - [ ] Visiting researcher
  - [ ] Other
- **Resubmission or follow-up: n/a**

ALIGNMENT / CALL

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Natural or biocompatible antimicrobial mat.

The objective of this activity is to develop materials suitable for application in antifungal / antimicrobial surface treatment in confined inhabited environment of manned spacecraft / habitat, such as ISS. The activity shall focus on reduction of bioburden in human spaceflight as the main goal. The developed materials shall fulfil minimum requirements:

Combination AM Nanostructuration

TR-1: The surface treatment shall ensure that the levels of microbial / fungal contamination defined for in-flight surfaces by MORD [AD3] are not exceeded.

High cross-linking No harmful mat.

TR-2: The surface treatment shall not leach harmful substances (including heavy metals) into the environment (air and water).

No harmful mat.

TR-3: The production process shall not involve any substance from the REACH candidate list.

Low qty No harmful mat.

TR-4: The off-gassing characteristics of the surface treatment shall be compatible with [AD1] for applications in confined space of manned spacecraft.

High cross-linking

TR-5: The surface treatment shall display long-term operational stability (at least 10 years), verified with accelerated ageing tests.

Nanomaterials

TR-6: The resulting surface shall be compatible with standard wipes (http://www.ront-paramed.com/sachets-chlorhexidine.html) used on ISS or self-cleaning

GOALS OF NBACTSPACE PROJECT

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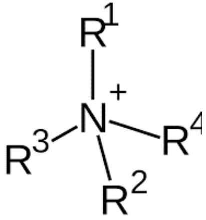
- Fabrication of coatings with easily up-scalable processes
- Coatings with:
  - A biocompatible matrix
  - Biocompatible biocides
  - Broad spectrum antimicrobial effect
  - Long-term activity
  - Resistance to mild mechanical stresses
  - Metal-free
  - No cytotoxic even at high dose
- For protecting both
  - aerial surfaces (structure, screens)
  - under water surfaces (water supply, etc)

WHAT IS THE PROBLEM TO BE SOLVED?

Problem to be solved

Replacement of conventional AM materials (e.g. Ag, TiO_2, QACs) and coatings (non degradable or toxic synthetic polymers) by sustainable and safe natural materials & coatings



New processes

Alternative materials

Alternative coatings

What we want :

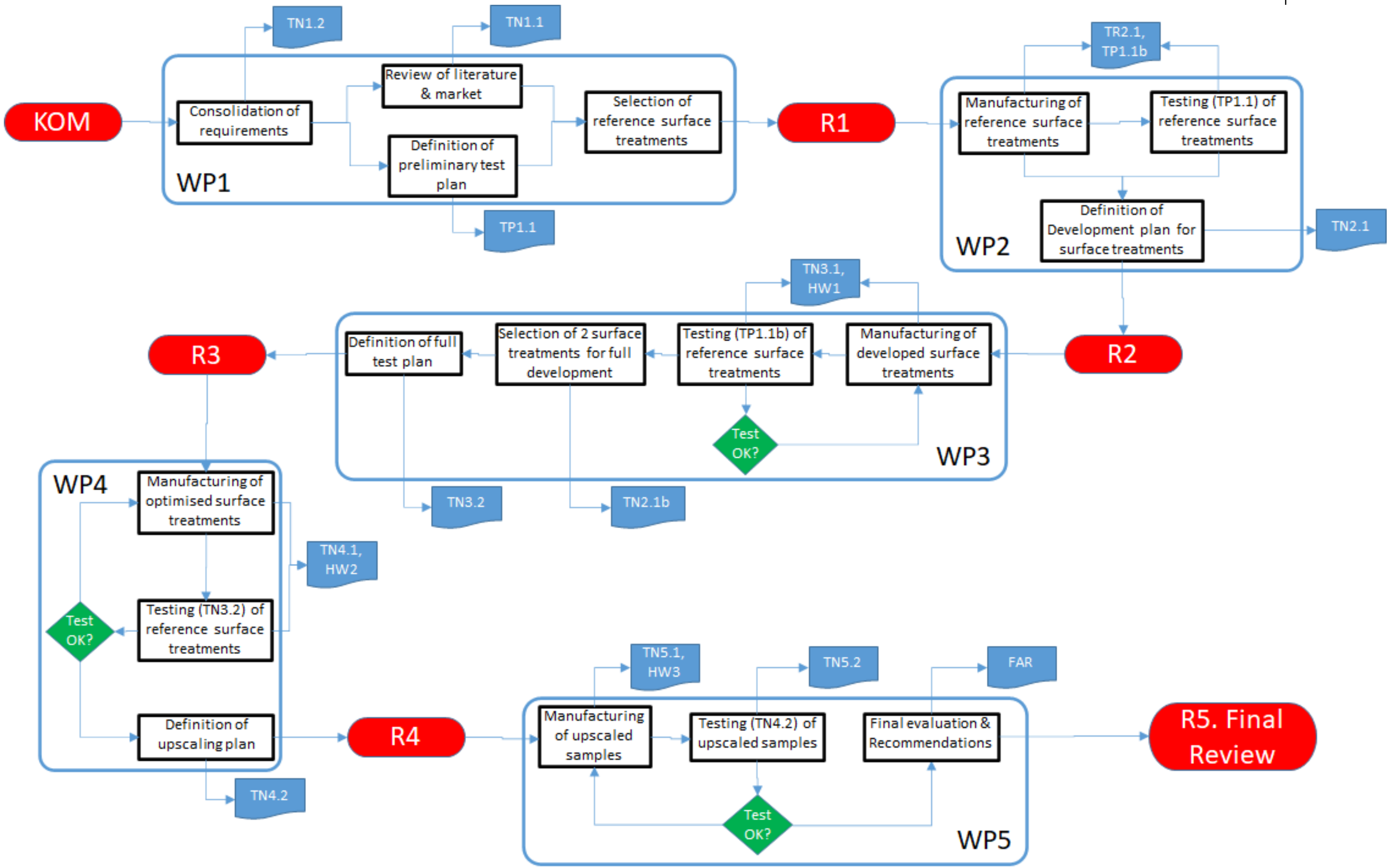
(i) bio-based materials and coatings, sustainable- and safe-by-design

(ii) based on plasma or colloidal engineering

(iii) Safe, compliant and efficient AM coating manufacturing processes

(iv) Durable (10 years)

WORK PLAN



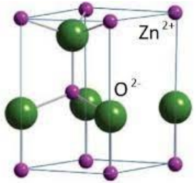
KOM
Consolidation of requirements
TN1.2
Review of literature & market
TN1.1
Definition of preliminary test plan
TP1.1
Selection of reference surface treatments
WP1
R1
TR2.1, TP1.1b
Manufacturing of reference surface treatments
Testing (TP1.1) of reference surface treatments
Definition of Development plan for surface treatments
TN2.1
WP2
R2
TN3.1, HW1
Manufacturing of developed surface treatments
Testing (TP1.1b) of reference surface treatments
Test OK?
Selection of 2 surface treatments for full development
Definition of full test plan
TN3.2
TN2.1b
WP3
R3
WP4
Manufacturing of optimised surface treatments
TN4.1, HW2
Testing (TN3.2) of reference surface treatments
Test OK?
Definition of upscaling plan
TN4.2
R4
TN5.1, HW3
Manufacturing of upscaled samples
TN5.2
Testing (TN4.2) of upscaled samples
Test OK?
FAR
Final evaluation & Recommendations
WP5
R5. Final Review

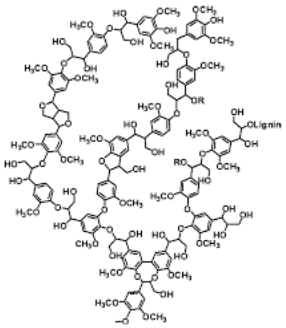
ANTIMICROBIAL COMPOUNDS USED

3 kinds of antimicrobial agents to kill viruses, bacteria, fungi, parasites:

1) Metal oxide => **ZnO** :

- Currently the most biocompatible oxide based broad spectrum antimicrobial agent



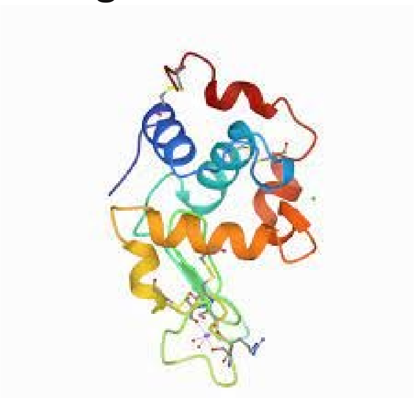


2) **Biosourced organic** molecules => **chitosan, lignin**

- Many products under development and reaching the market now mainly for food preservation

3) **Biomolecules** => **antimicrobial peptides**

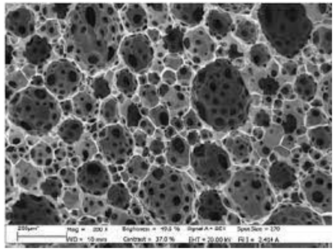
- widely used in food safety and biomedical applications for antibacterial purposes



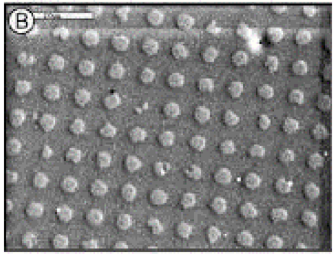
COATING MATRIX USED

3 kinds of coating matrix to provide adhesion & durability:

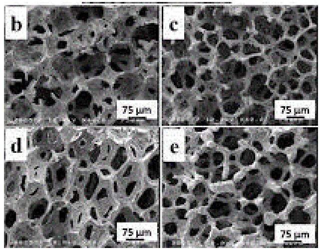
1) **Synthetic organic** => **methacrylate**-based:
- Currently used for medical devices, scaffolds



2) **Hybrid** => **HMDSO**-based, PDMS-like :
- Currently used for medical devices, scaffolds

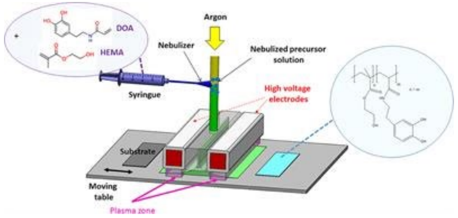


3) **Synthetic organic** => **Poly (vinyl alcohol)**-based :
- Currently used for medical devices, scaffolds

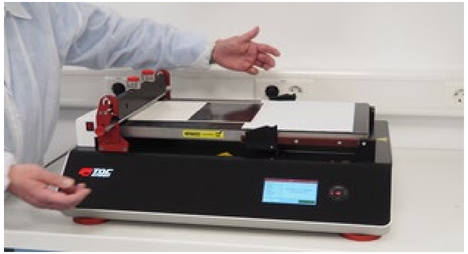


DEPOSITION PROCESSES USED

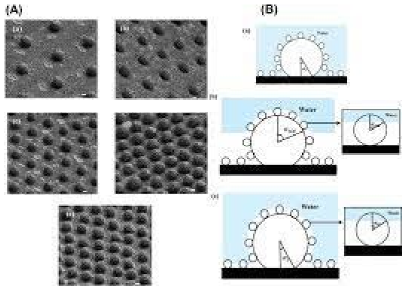
3 kinds of coating processes to provide easy up-scaling:



1) **Atmospheric-pressure deposition => DBD**
   - higher mechanical strength, no solvent



2) **Wet deposition** => **bar coating**:
   - mature technology, simple, easy up-scale



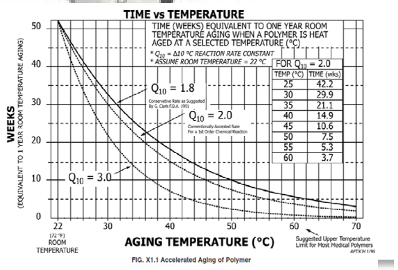
3) **Nanopatterning** => **colloidal lithography**:
   - emerging techno, high control at nanoscale

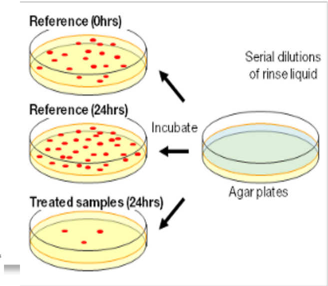
CHARACTERIZATION/TESTS PLAN

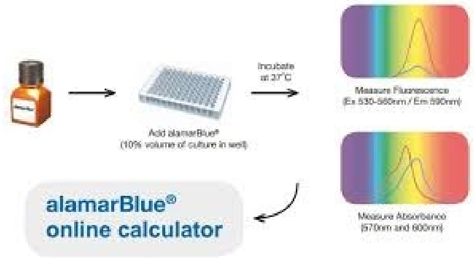
1- Coating 1 on steel
2- Coating 2 on steel
3- Coating 1 on kapton
4- Coating 2 on kapton

Samples:
8 -10 x 10 cm2
45 - 5 x 5 cm2
20 - 1 x 1 cm2

- For ESA (2 samples 10 x 10cm2)
- Initial bacterial adhesion & biofilm growth (10 samples)
- Corrosion test (3 samples)
- Surface resistivity (2 samples)
- SEM/EDS & HIM (17 samples) → AFM/profilo. & WCA (17 samples)
  - → Off-gassing (2 samples)
  - → Wipe's test (2 samples)
  - → Accelerated Ageing (13 samples) → Antimicrobial activity (5 samples)
- Adhesion (3 samples)
- Antimicrobial & antifungal activity ISO22196:2011 (15 samples)
- Cytotoxicity testing (20 samples 1 x 1 cm2)
- Immersion (2 samples) 10 x 10 cm2
  - → LCMS/ToF-SIMS analyses (3 eluants)
  - → Weighting, pH (2 samples)







CHARACTERIZATION/TESTS PLAN

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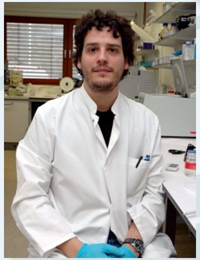
Biological tests


T. Serchi


H.-M. Cauchie

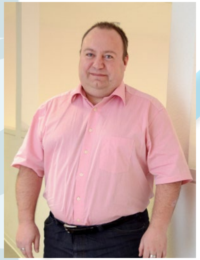

D. Collard


M. Michel


JS. Beltran

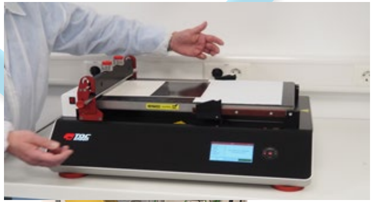

S. Krishnamoorthy

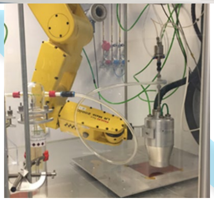

J.-S. Thomann


M. Scolan


R. Quintana

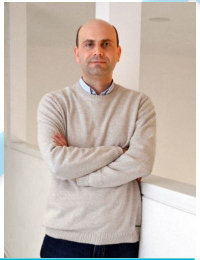

D. Duday





Nanoparticles & Coatings


E. Angst


J. Guillot


G. Frache


J. Bour

Physico-chemical tests

NN staff	JS Beltran, I. Mesmoudi	CDD
NN Staff	HM Cauchie, T. Serchi, M. Michel, G. Guerriero , S. Krishnamoorthy, P. Choquet, R. Quintana, JS. Thomann, J. Guillot, J. Bour, G. Frache, C. Vergne, S. Gaillard, E. Angst, B. El Adib, JN Audinot, JL Biagi, S. Contal, T. Gaulain, L. Solhinac, D. Collard, A. Chary, S. Perbal, T. Girot, L. Chochois	CDI
Coordination	D. Duday	CDI


T. Girot


L. Chochois

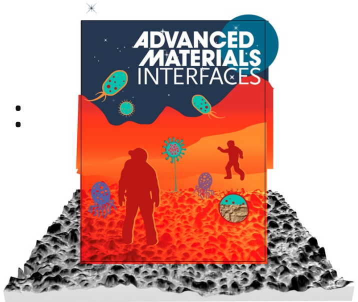

S. Perbal

Partnership, Regulation, Technomarket

II – Main outcomes

OUTCOMES WP1

4 main outcomes:



1) **Full review of R&D and commercial antimicrobial coatings** :

- leading to a review paper published in 2021
- weekly alert on patent database

2) **Pre-selection of 6 commercial coatings and selection of 2 as reference:**

- Nitropep and SCS Microresist (organic-based)

Solutions	Metal-free	Bact. resist.	Space Maturi.	Toxicity	Abrasion	Heat	Literature	Total
AGXX	X	V	V	X	V	V	V	5
Nitropep	V	V	V	V	X	X	V	5
Microresist	V	V	V	V	V	X	X	5
AMBIO	V	X	X	V	X	X	V	3
PSI-QAC	V	V	V	V	X	X	X	4
Biosafe	V	V	V	V	X	X	V	5

OUTCOMES WP1

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY LIST

4 main outcomes:

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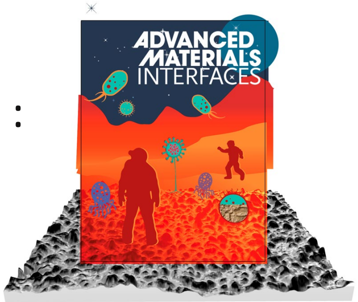

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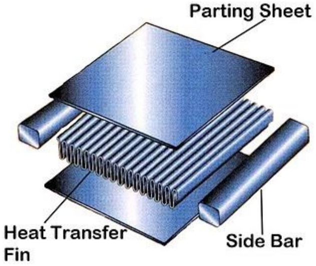
AGXX	X	V	V	X	V	V	V	5
Nitropep	V	V	V	V	X	X	V	5
Microresist	V	V	V	V	V	X	X	5
AMBIO	V	X	X	V	X	X	V	3
PSI-QAC	V	V	V	V	X	X	X	4
Biosafe	V	V	V	V	X	X	V	5

OUTCOMES WP1

3) Consolidation of requirements

Selected application 1: Water condensing surfaces

Why ? -Surfaces more prone to microbial proliferation in spacecraft
-No access for cleaning, no possibility of replacement



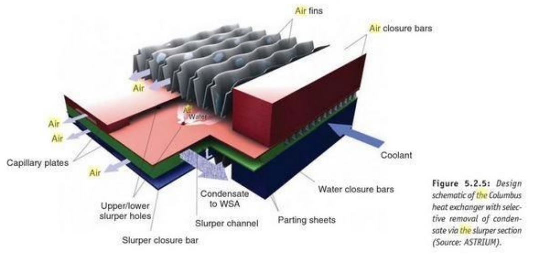


Figure 5.2.5: Design schematic of the Columbus heat exchanger with selective removal of condensate via the slurper section (Source: ASTRIUM).

Stainless steel

Selected application 2 : All “dry” surfaces in Spacecrafts

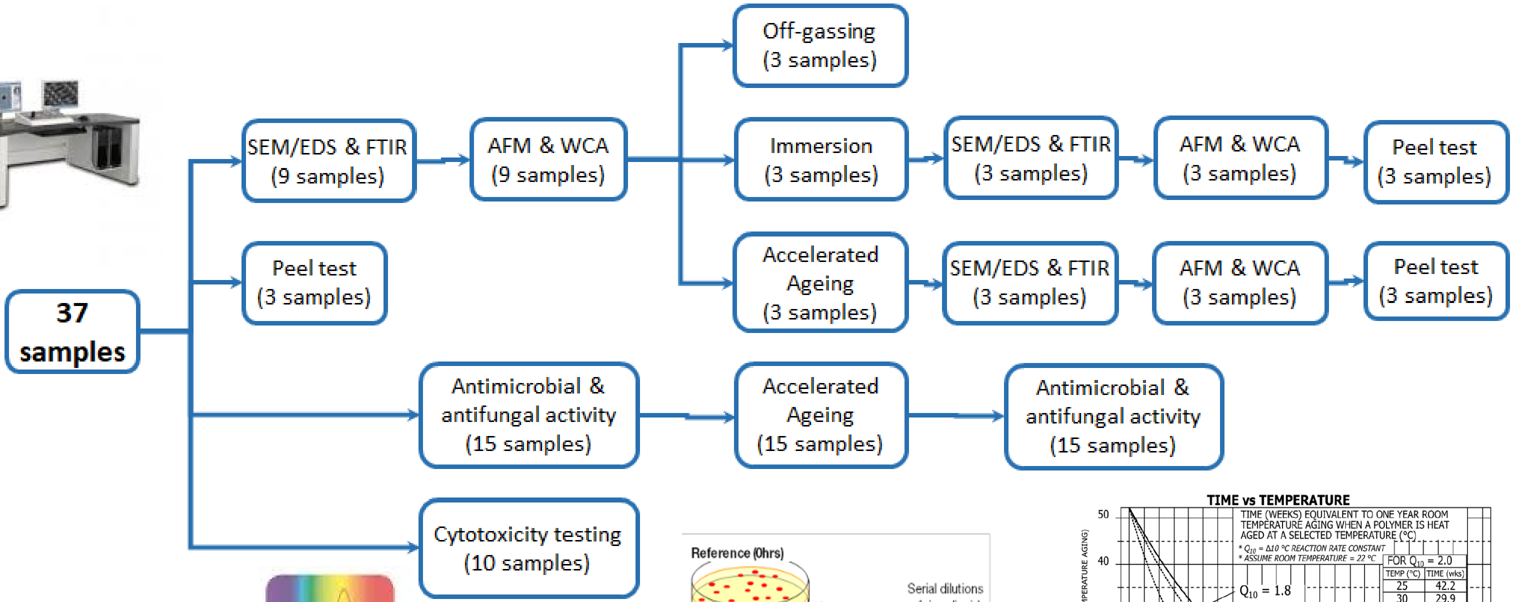
Why ?

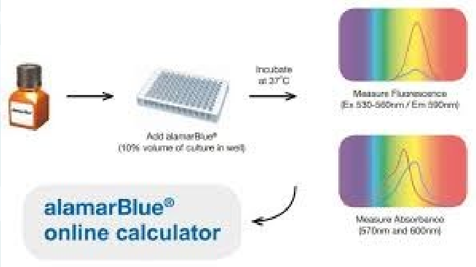
- Microbial proliferation in direct contact are with crews
- Microbial proliferation in hidden/inaccessible areas where contaminated drops, debris, dusts can accumulate
- Parts that cannot be changed

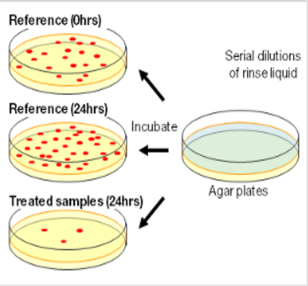
Kapton

OUTCOMES WP1

4) Preliminary test plan







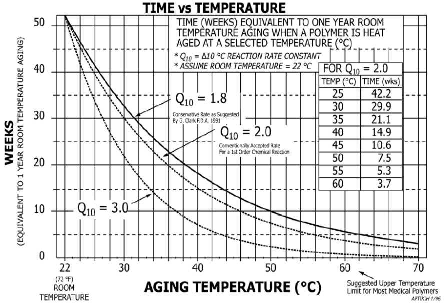


FIG. X1.1 Accelerated Aging of Polymer

OUTCOMES WP2

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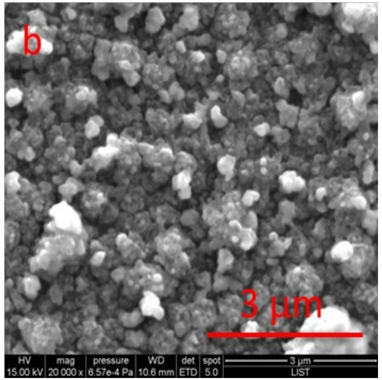
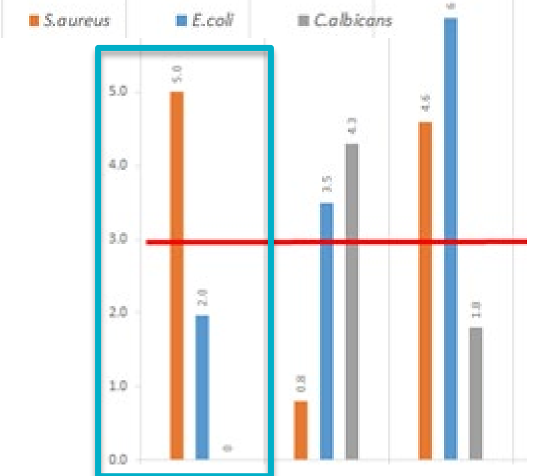
4 main outcomes:

1) **Prod./Charact./Test of commercial reference 1**:
- solution 1 prepared at Nitropep:
covalent bonding of chlorhexidine on steel

SEM



Antmicrobial efficiency (log red. vs control)



Nitropep /steel | Microresist /steel | Microresist /kapton

Wipe test

Off-gassing

CAS-Nr.	Substance	Test chamber concentration [µg/m³]	SMAC [µg/m³]	Mass [µg]	PSC [µg/m³]	T ind
630-08-0	Carbon monoxide	n.d.	63.000	0,0000	0,0E+00	0,0E+00
74-82-8	Methane	n.d.	3.500.000	0,0000	0,0E+00	0,0E+00
111-65-9	n-Octane	62	280.000	0,0930	9,3E-04	3,3E-09
124-18-5	n-Decane	12	232.380	0,0180	1,8E-04	7,7E-10
111-66-0	1-Octene	10	228.190	0,0150	1,5E-04	6,6E-10
66-25-1	n-Hexanal	42	20.000	0,0630	6,3E-04	3,2E-08
111-71-7	n-Heptanal	14	23.000	0,0210	2,1E-04	9,1E-09
124-13-0	n-Octanal	51	26.000	0,0765	7,7E-04	2,9E-08
124-19-6	n-Nonanal	136	29.000	0,2040	2,0E-03	7,0E-08
143-08-8	n-Nonanol	15	58.900	0,0225	2,3E-04	3,8E-09
various	unidentified fatty acid alkyl esters*1)	12	100	0,0180	1,8E-04	1,8E-06

µg = microgram = 1 millionth gram
detection limit: 10 µg/m³
*1) = estimated by the response of n-Butylacetate

n.d. = not detected

T-value = ΣT_{ind}

K 9482 FM	T-value =	0,000002

The acceptance level of the T-value < 0,5 is maintained.

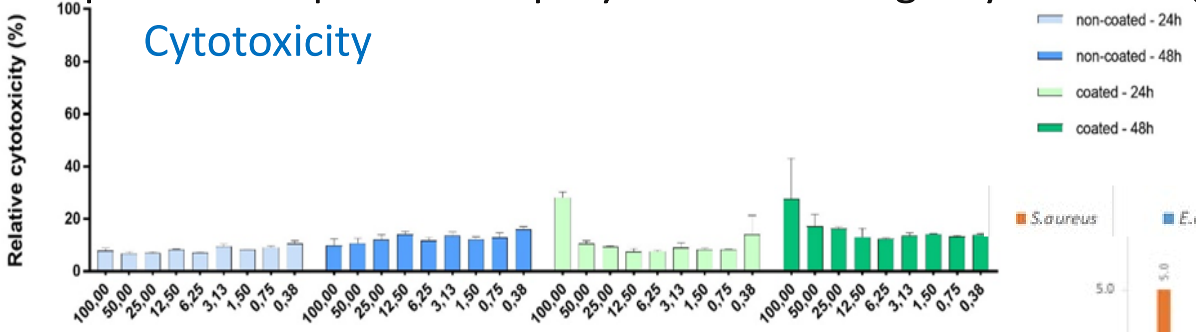
T value = 2.10^{-6}

OUTCOMES WP2

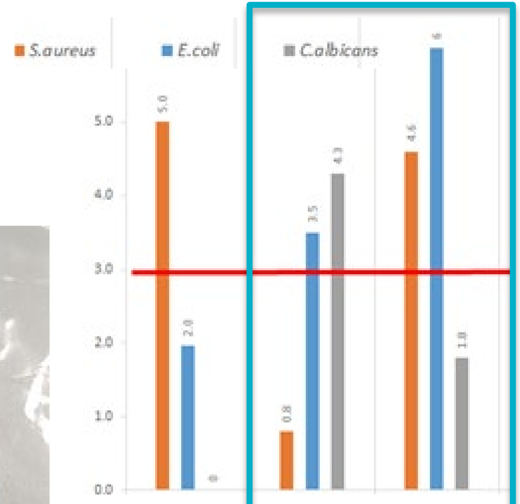
2) **Prod./Charact./Test of commercial reference 2**:

Low-pressure deposition of parylene containing a synthetic organic AM at SCS

Cytotoxicity



Antimicrobial activity

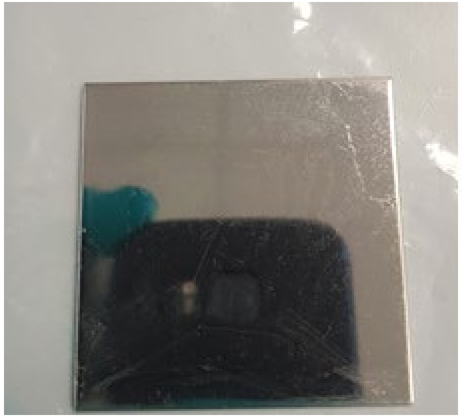


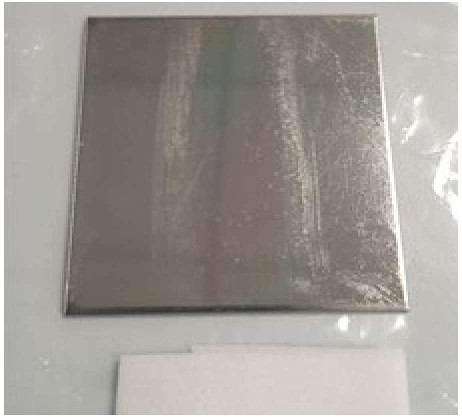
Nitropep /steel

Microresist /steel

Microresist /kapton

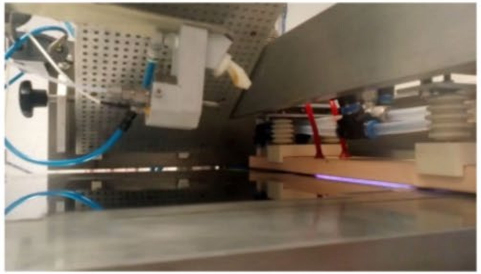
Wipe test

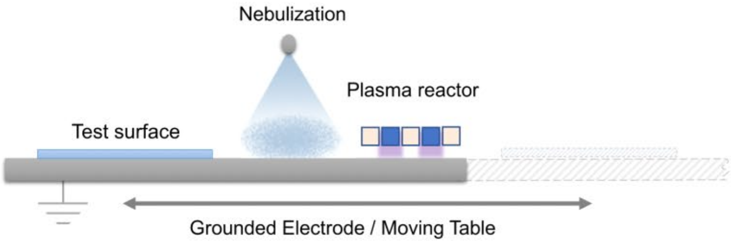


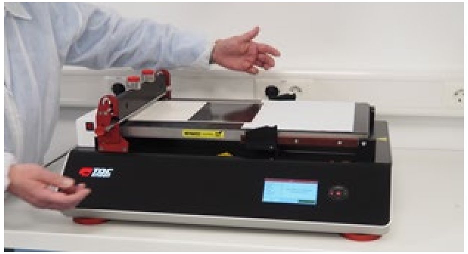


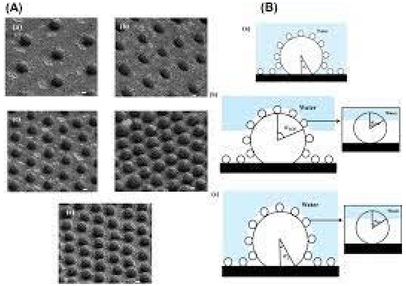
OUTCOMES WP2

3) **Manufacturing plan for 5 LIST coatings**









4) **Regulatory screening of compounds proposed**

Conclusion Benchmark 3	Use – No regulatory constraints/substitution need identified	Continue to monitor

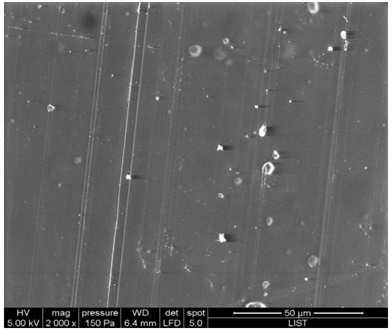
OUTCOMES WP3

5 main outcomes:

1) **Prod./Charact./Test of LIST coating 1**:

- Plasma Methacrylate-based + DOPA + AM peptide

SEM



Compo-XPS

Sample Identifier	B 1s %	C 1s %	Ca 2p %	Cl 2p %	N 1s %	O 1s %	P 2s %	S 2p %	Si 2p %
ROQUC57-pt1	0.0	68.5	0.0	0.0	2.9	28.5	0.2	0.0	0.0
ROQUC57-pt2	0.0	68.8	0.0	0.0	3.3	27.7	0.2	0.0	0.0
ROQUC57c-pt1	0.0	70.7	0.0	0.1	10.5	18.4	0.0	0.3	0.0
ROQUC57c-pt2	0.0	71.2	0.0	0.2	10.2	18.2	0.1	0.3	0.0

Antimicrobial efficiency (log red. vs control)

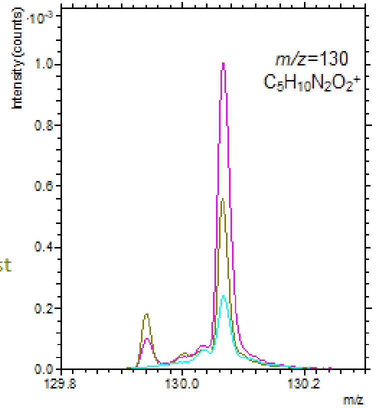
➢ No antibacterial effect detected

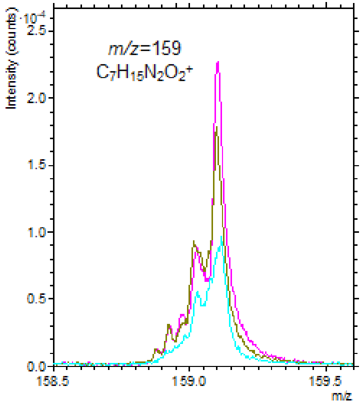
Wipe test

Plasma film
+ lysozyme

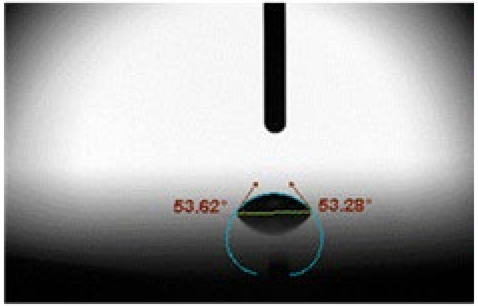
Plasma film
+ lysozyme
after adhesion test

Plasma film
+ lysozyme
after corrosion





WCA



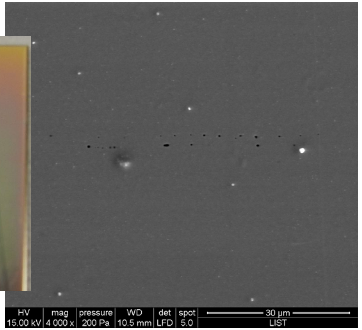
OUTCOMES WP3

2) **Prod./Charact./Test of LIST coating 2**:

- Plasma DBD HMDSO coating

Optical

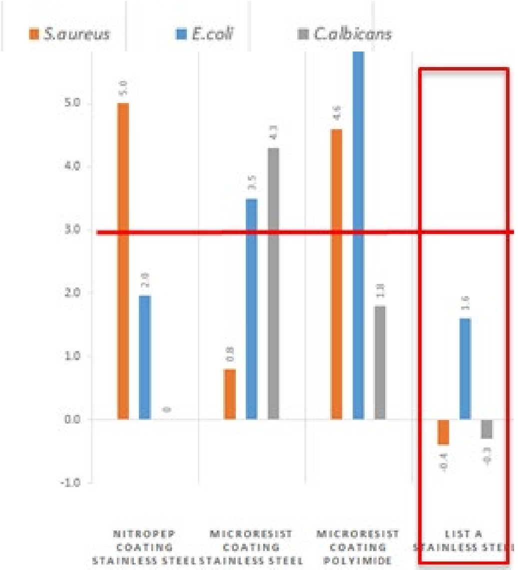
SEM



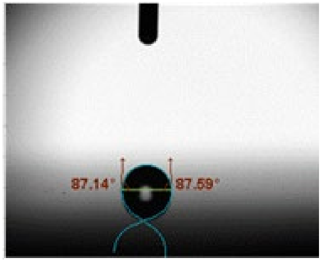
Compo-XPS

Sample Identifier	C 1s %	N 1s %	O 1s %	Si 2p %
ROQNC-52-Pt1	44.1	4.2	30.6	21.1
ROQNC-52-Pt2	44.4	4.0	29.9	21.7
ROQNC-52-Pt3	45.6	4.2	28.8	21.4

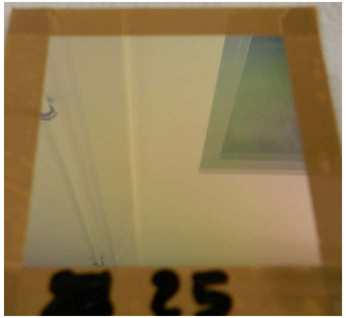
Antimicrobial efficiency (log red. vs control)



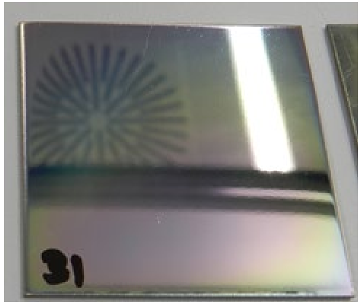
WCA



Wipe test



Ageing test



OUTCOMES WP3

3) **Prod./Charact./Test of LIST coating 3**:

- PVA-based with boric acid & lignin NPs

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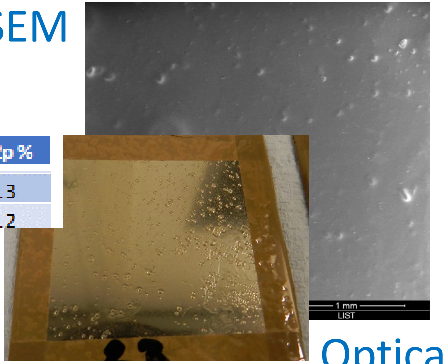
Compo-XPS

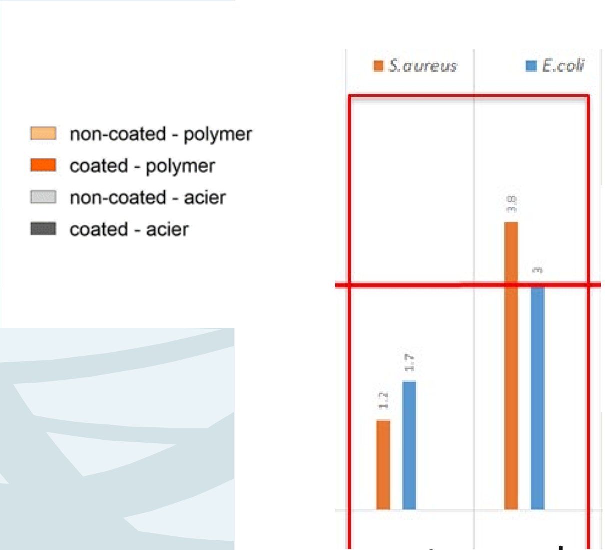
Sample Identifier	B 1s %	C 1s %	Ca 2p %	Cl 2p %	N 1s %	O 1s %	P 2s %	S 2p %	Si 2p %
PVA_lignin_NP-pt1	0.9	82.4	1.7	0.0	0.0	14.5	0.0	0.2	0.3
PVA_lignin_NP-pt2	1.0	83.0	1.7	0.0	0.0	14.1	0.0	0.1	0.2

SEM



Optical

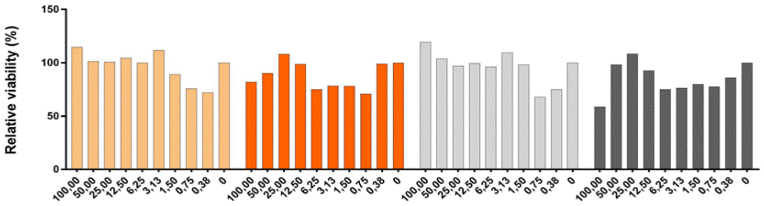
Antimicrobial efficiency (log red. vs control)



on steel

on kapton

Cytotoxicity



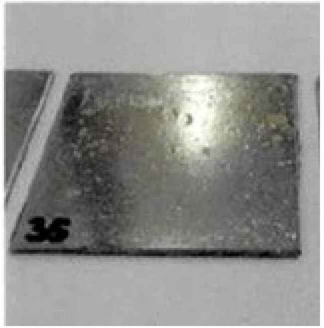
Kapton

Coat. on kapton

Steel

Coat. on steel

Ageing

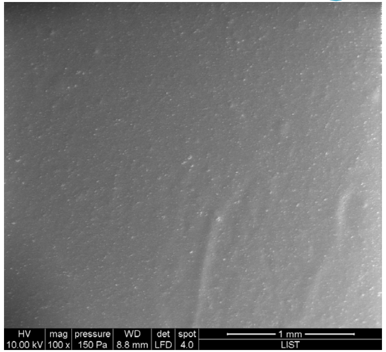


OUTCOMES WP3

4) **Prod./Charact./Test of LIST coating 4**:

- PVA-based with boric acid & SiO2-peptide NPs

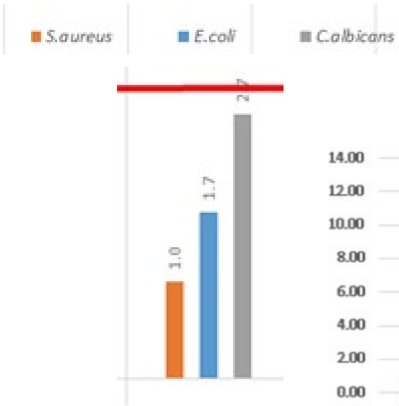
SEM



Compo-XPS

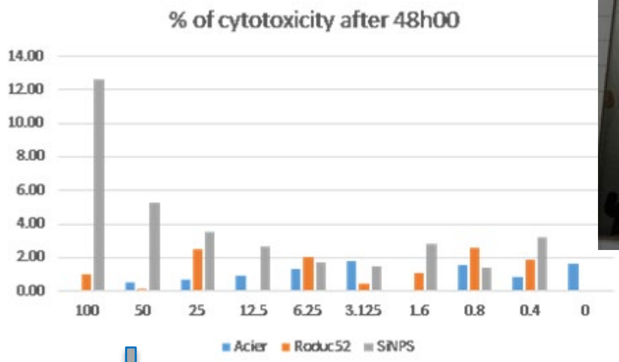
Sample Identifier	B 1s %	C 1s %	Ca 2p %	Cl 2p %	N 1s %	O 1s %	P 2s %	S 2p %	Si 2p %
PVA_lignin_NP-pt1	0.9	82.4	1.7	0.0	0.0	14.5	0.0	0.2	0.3
PVA_lignin_NP-pt2	1.0	83.0	1.7	0.0	0.0	14.1	0.0	0.1	0.2
PVA_silica_NP-pt1	2.2	74.6	1.0	0.0	0.4	21.5	0.0	0.1	0.3
PVA_silica_NP-pt2	2.4	72.8	0.8	0.0	0.5	23.2	0.0	0.1	0.2

Antimicrobial efficiency (log red. vs control)



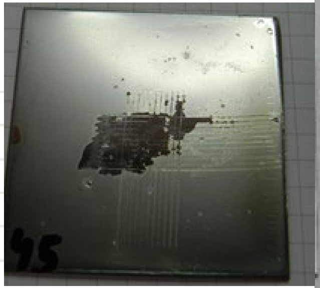
on steel

Cytotoxicity

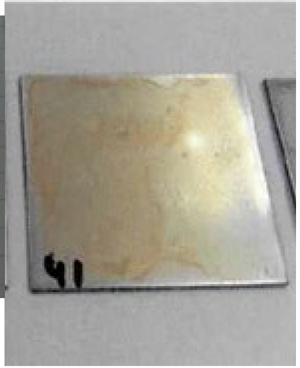


PVA-based coatings

Adhesion test



Ageing

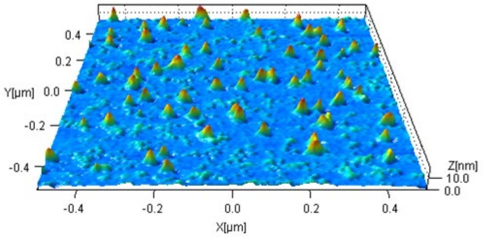


OUTCOMES WP3

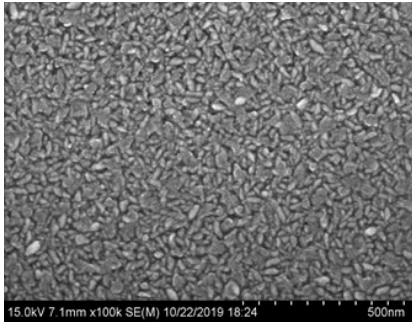
5) **Prod./Charact./Test of LIST coating 5**:

- nanopatterned ZnO surface

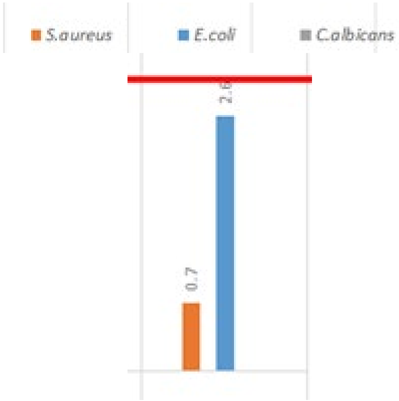
AFM



SEM

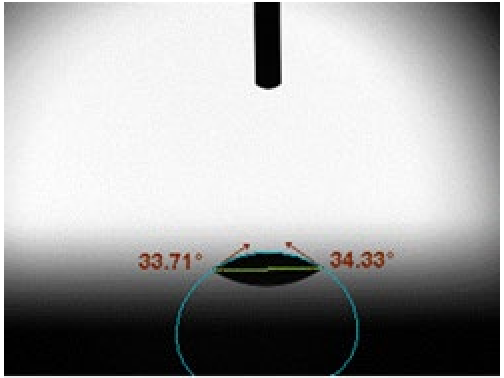


Antimicrobial efficiency (log red. vs control)

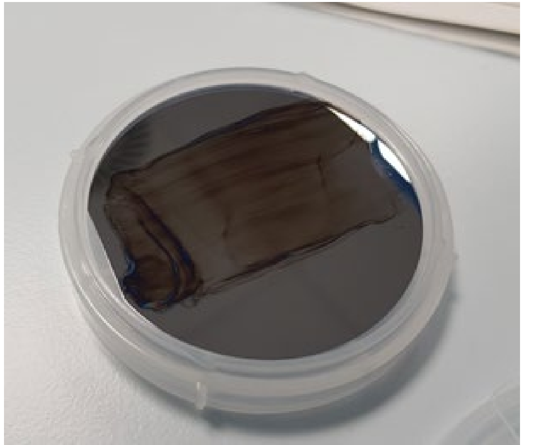


on silicon

WCA



Wipe test



OUTCOMES WP3
COMPARATIVE TABLE & SELECTION

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	PP-EGDMA Lyso	PP-HMDSO	PVA-LIGNIN NPs	PVA-Lyso NPs	np-ZnO
WCA	54	90 ++	51	54	34
E. coli	-	++	++	++	++
S. aureus	-	-	+	+	+
A. niger	-	-	++	+	-
Adhesion	++	++	+	-	--
Corrosion	++	++	++	+	-
Ageing	++	++	++	+	
Immersion	++	++	+	+	-
Aspect	++	++	-	-	++
Cytotoxicity	++	++	+	++	++
Up-scaling	+	++	++	+	-
Ranking	5	2	1	3	4

OUTCOMES WP4

2 main outcomes:

1) **Prod./Charact./Test of LIST optimized wet coating 1**:

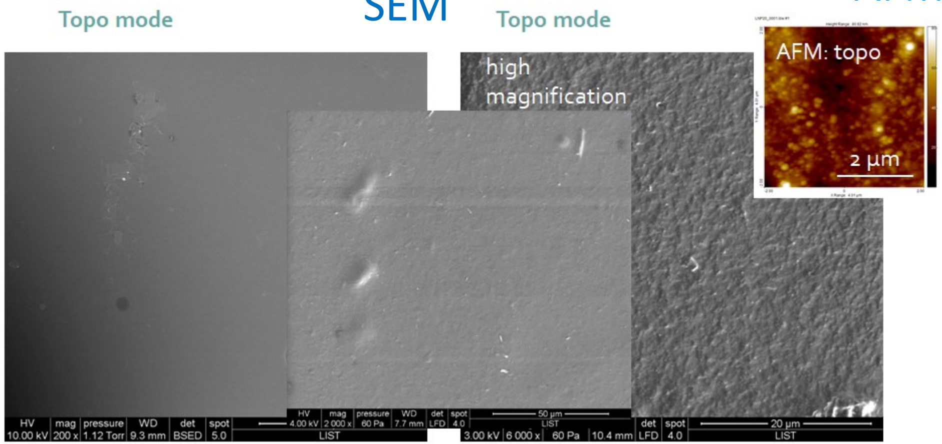
- Wet PVA-based coat. + chitosan + Lignin NPs

Compo-XPS

Sample Identifier	C 1s %	Cl 2p %	N 1s %	O 1s %	S 2p %	Si 2p %
ST-PEI5-THF075_pt1	75.4	0.1	1.5	22.1	0.1	0.8
ST-PEI5-THF075_pt2	76.0	0.1	1.6	21.3	<0.1	1.0
ST-PEI5-THF075_pt3	74.1	0.2	1.8	23.0	0.1	0.8

SEM

AFM

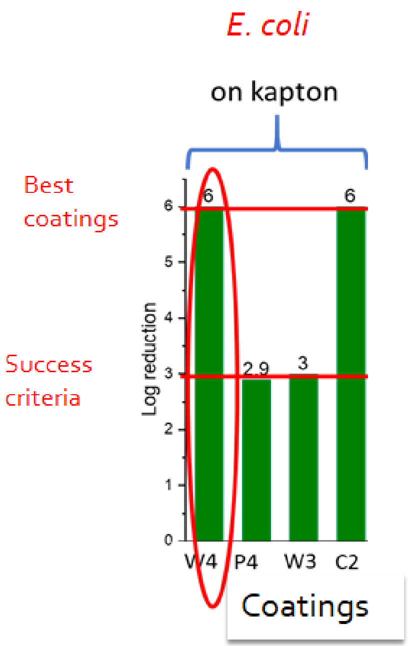


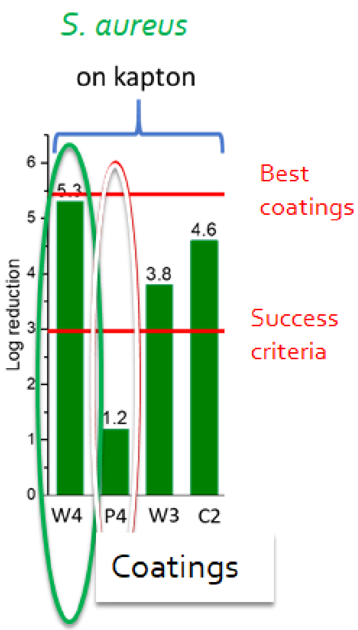
- At low magnification, homogenous and flat topography with a few defects
- At high magnification, orange skin-like topography

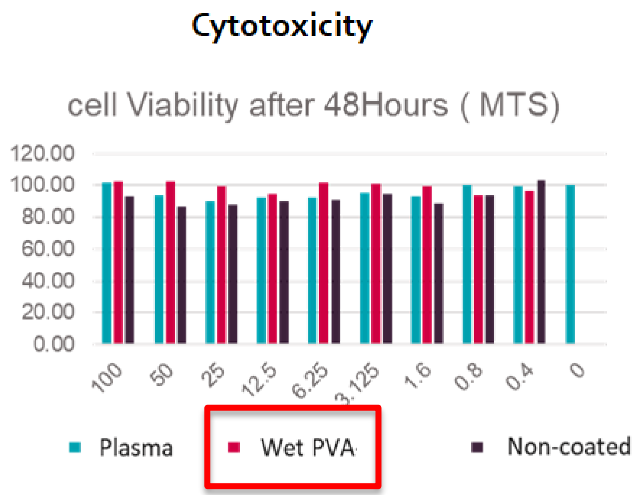
OUTCOMES WP4

1) **Prod./Charact./Test of LIST optimized wet coating 1**:

Effectiveness on *bacteria*







W4: optimized wet-processed PVA coatings
P4: optimized plasma HMDSO-based coatings
W3: non-optimized wet-processed PVA coatings
C2: Commercial reference metal-free coating

- Highly efficient against *E. coli* and *S. aureus*
- No cytotoxicity detected

=> High selectivity on bacterial cells

OUTCOMES WP4

1) **Prod./Charact./Test of LIST optimized wet coating 1**:

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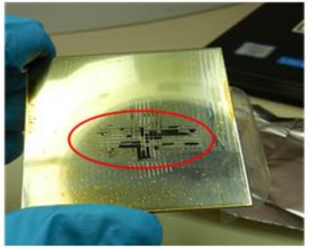
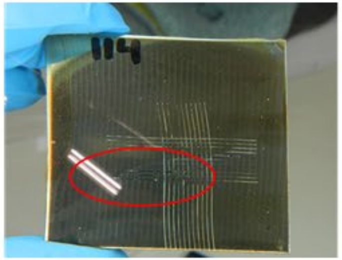
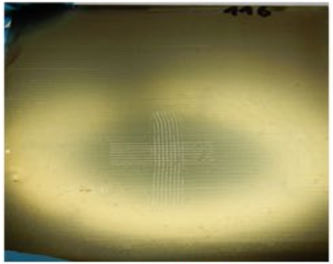
Adhesion test with 4.2 N/cm tape



Cleaning with ethanol

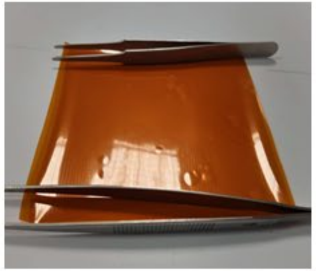


Cleaning with acetone

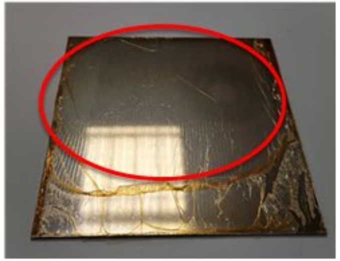


Cleaning with alkaline soap

Immersion 24h in DI water

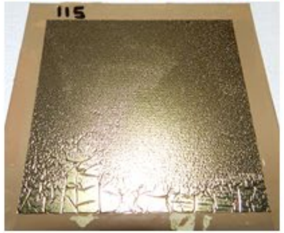


on kapton



on steel

Salt spray testing 1 week



on steel

- Wet-processed PVA-based coatings resist to the harsh corrosion test on steel and kapton but some local adhesion failure occurs due to salty water absorption

- Wet-processed PVA-based coatings resist to the harsh adhesion test on steel and kapton when the pre-treatment steps (cleaning with alkaline soaps and UV ozonation) are efficient
- Wet-processed PVA-based coatings resist to immersion test on steel and kapton when the coating is well adherent, homogenous and not too thick

OUTCOMES WP4

2 main outcomes:

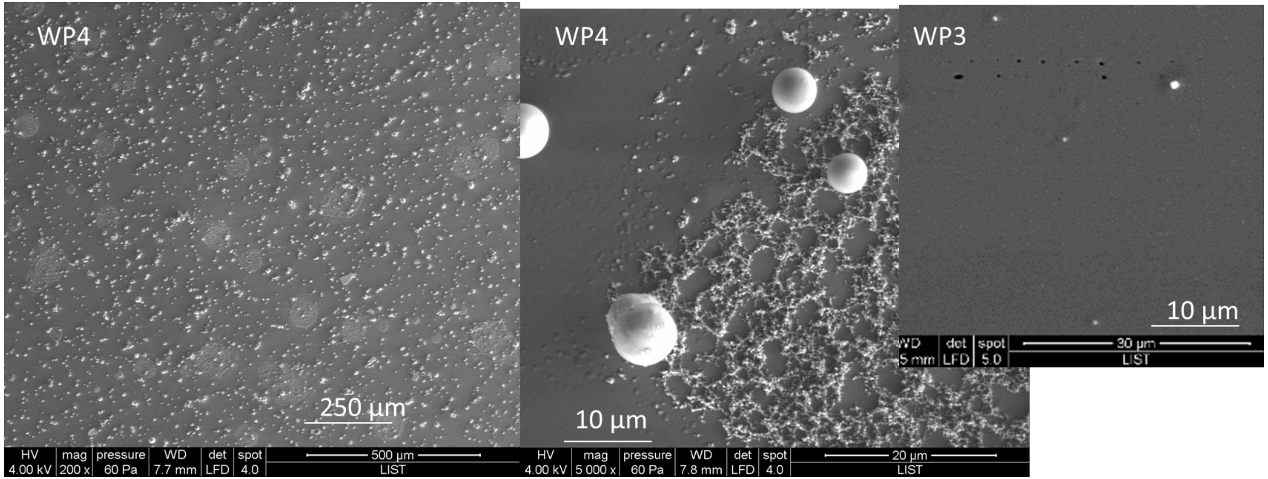
2) **Prod./Charact./Test of LIST optimized plasma coating 2**:

- Plasma HMDSO-based coat. + lignin molecules

Compo-XPS

Sample Identifier	C 1s %	N 1s %	O 1s %	Si 2p %
ROQUC86_4_pt1	43.7	1.4	35.1	19.7
ROQUC86_4_pt2	44.0	1.5	35.3	19.2
ROQUC86_4_pt3	44.5	1.5	34.9	19.2

SEM



OUTCOMES WP4

2) **Prod./Charact./Test of LIST optimized plasma coating 2:**

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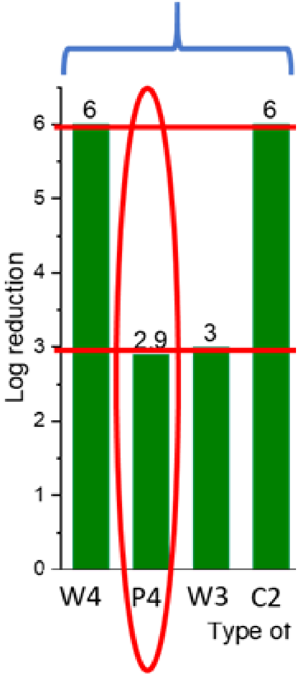
Antimicrobial efficiency (log red. vs control)

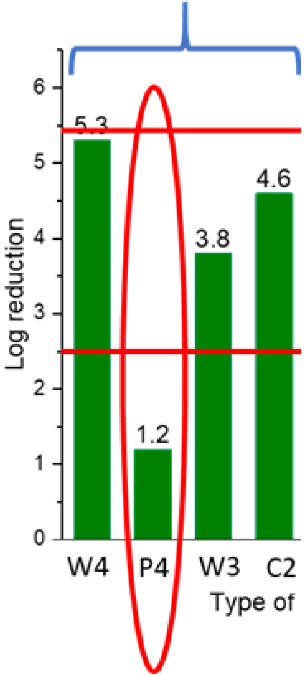
E. coli

on kapton

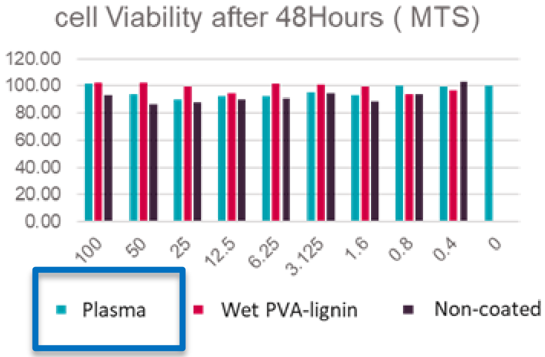


S. aureus

on kapton



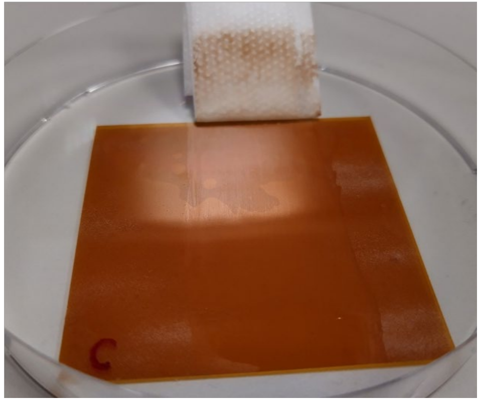
Cytotoxicity



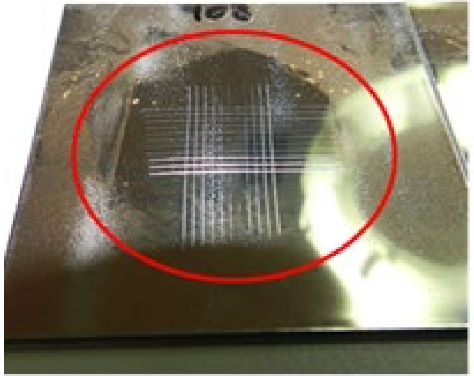
OUTCOMES WP4

2) **Prod./Charact./Test of LIST optimized plasma coating 2**:

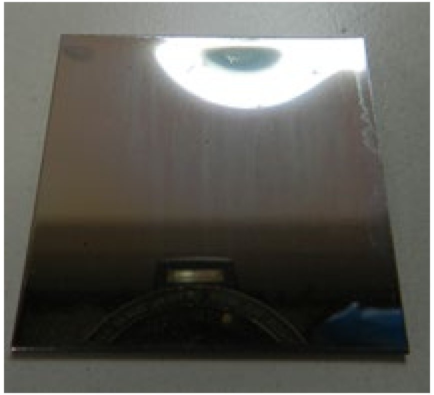
After wipe's test



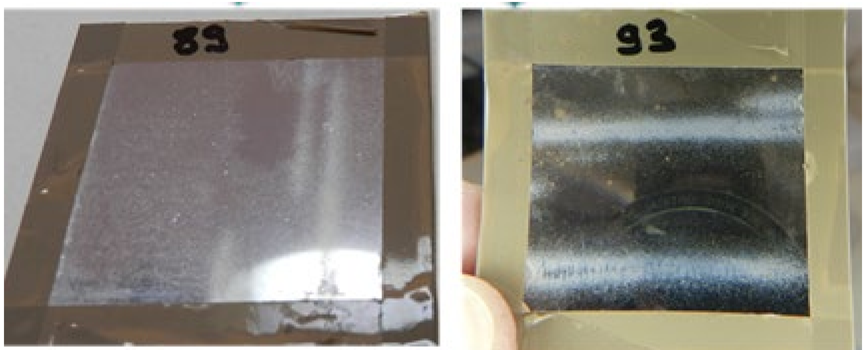
Adhesion test



Immersion test



Corrosion test



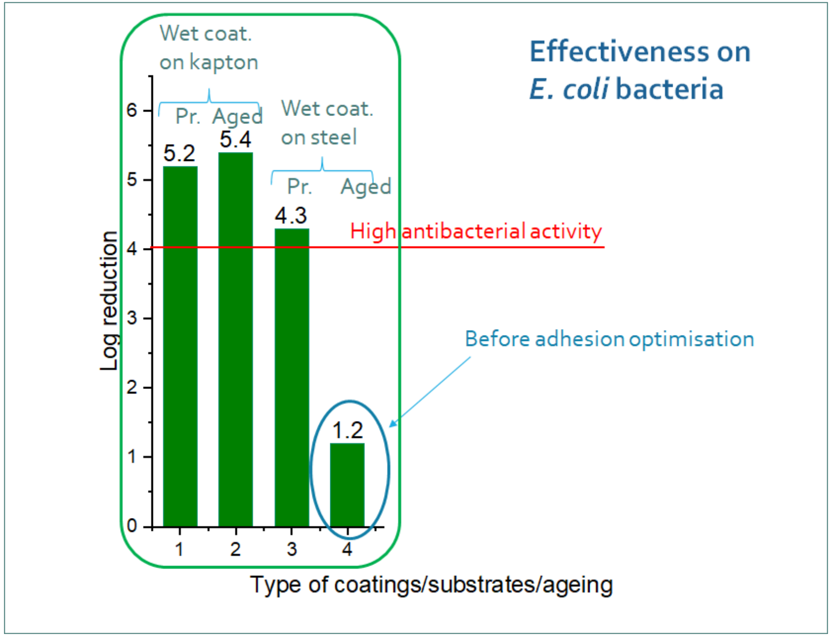
OUTCOMES WP5

2 main outcomes:

1) **Prod./Charact./Test of LIST upscaled wet coating 1**:

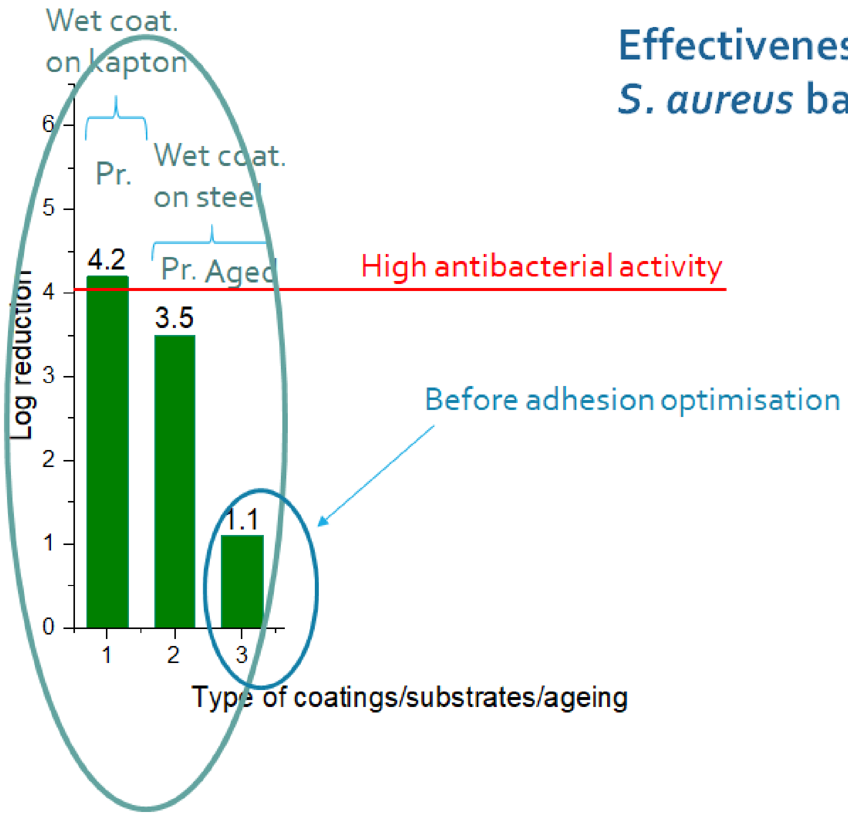
- Wet PVA-based coat. + chitosan + Lignin NPs

Antimicrobial efficiency (log red. vs control)



OUTCOMES WP5

1) **Prod./Charact./Test of LIST upscaled wet coating 1**:

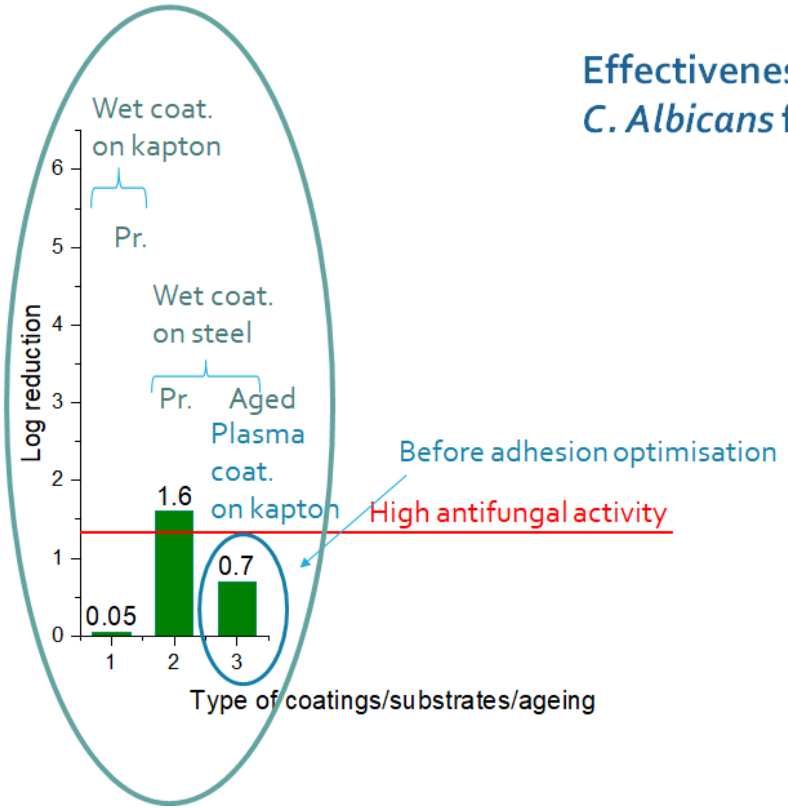


Effectiveness on
S. aureus bacteria

OUTCOMES WP5

1) **Prod./Charact./Test of LIST upscaled wet coating 1**:

Effectiveness on
C. Albicans fungi

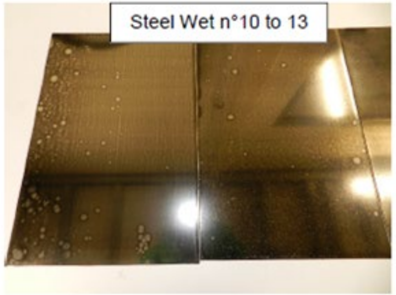


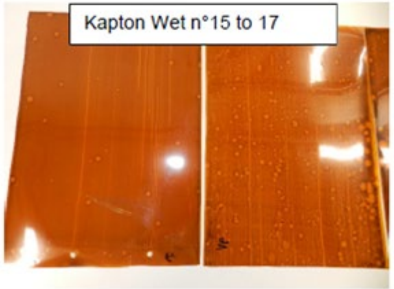
OUTCOMES WP5

1) **Prod./Charact./Test of LIST upscaled wet coating 1**:

Before ageing

After ageing





- *A4 size samples*
- No evolution of the coating aspect after 3.5 months simulating several years of use
- Antibacterial properties still present after ageing

OUTCOMES WP5

1) **Prod./Charact./Test of LIST upscaled wet coating 1**:

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OFF-GASSING TEST ECSS-Q-ST-70-29C

V	volume of chamber = 1,47 L
V_{SC}	Spacecraft volume = 100 m³
$Mass_{abs}$	Overall absolute amount off-gassed from the item / payload [µg] = Emission in chamber / V
SMAC	Spacecraft Maximum Allowable Concentration [µg/m³] listed in NASA-database MAPTIS; in case a value can not be obtained a minimum level of 100 µg/m³ is defined
PSC	Projected Spacecraft Concentration based on amount of compound emission in chamber related to spacecraft volume
T_{ind}	individual Toxicity value of compound = PSC/SMAC

CAS-Nr.	Substance	Test chamber concentration [µg/m³]	SMAC [µg/m³]	Mass [µg]	PSC [µg/m³]	T_{ind}
1634-04-4	tert-buthylmethylether	27	86.900	0,0398	4,0E-04	4,6E-09
66-25-1	n-hexanal	12	20.000	0,0177	1,8E-04	8,8E-09
64-19-7	acetic acid	115	7.400	0,1693	1,7E-03	2,3E-07
64-17-5	ethanol	953	2.000.000	1,4033	1,4E-02	7,0E-09

T-value = Σ T_{ind}

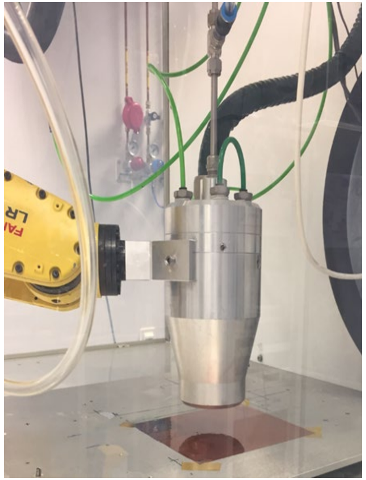
L 3738 FM	**T-value =**	**0,0000003**

The acceptance level of the T-value < 0,5 is maintained.

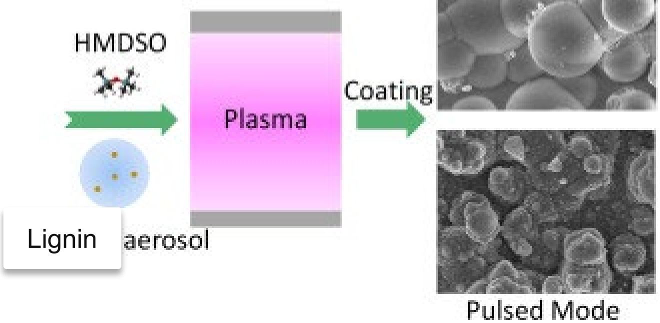
T-value = 3.10^{-7}

OUTCOMES WP5

2) **Prod./Charact./Test of LIST upscaled plasma coating 2**:

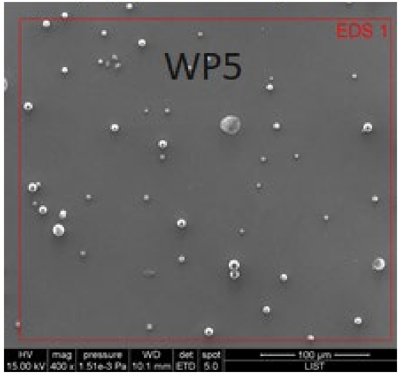


Principle



SEM

Topographic contrast picture



Compo-XPS

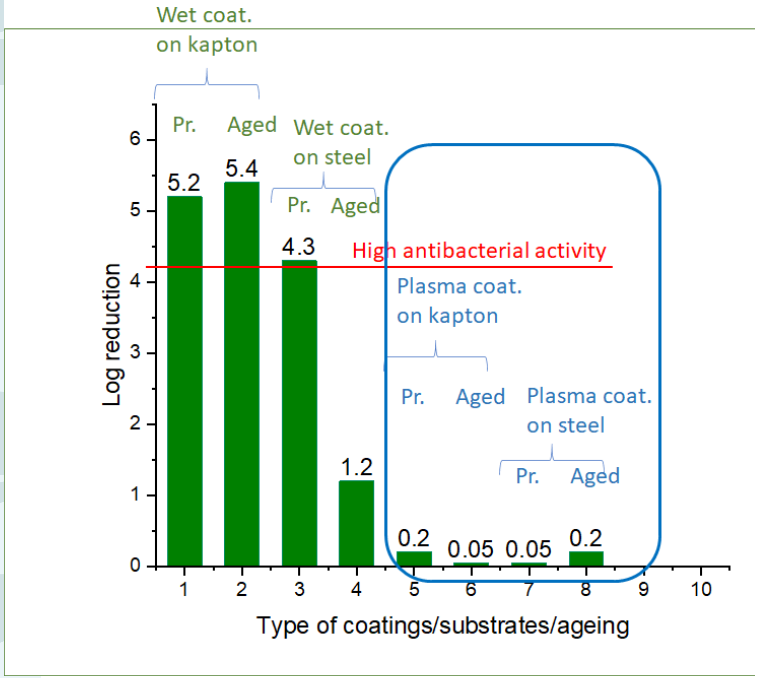
Sample Identifier	C 1s %	N 1s %	O 1s %	Si 2p %
NewPlasmaCoat-pt1	42.3	2.1	34.6	21.1
NewPlasmaCoat-pt2	42.9	2.0	34.1	21.1
NerwPlasmaCoat-pt3	42.1	1.9	34.6	21.3

OUTCOMES WP5

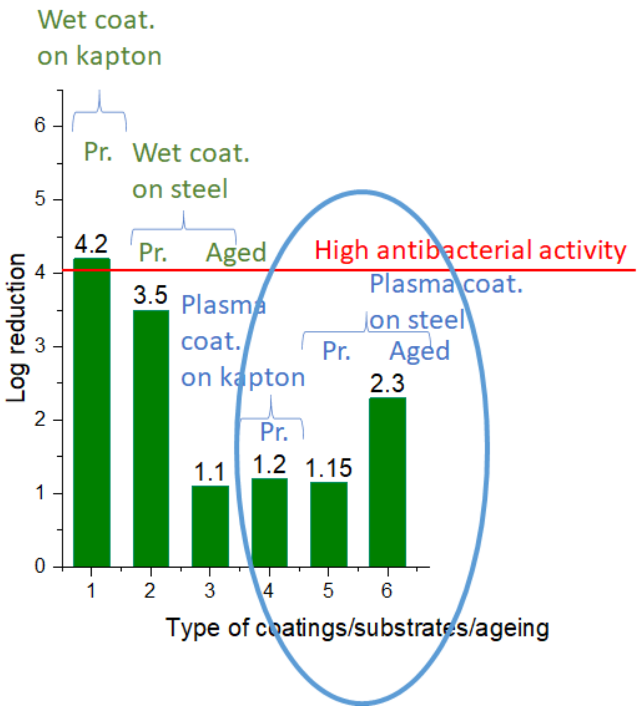
2) **Prod./Charact./Test of LIST upscaled plasma coating 2**:

Antimicrobial efficiency (log red. vs control)

E. coli



S. aureus



OUTCOMES WP5

2) Prod./Charact./Test of LIST upscaled plasma coating 2:

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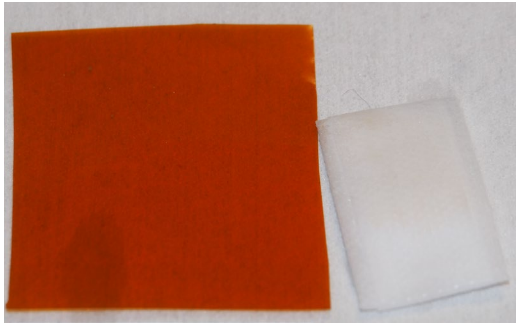
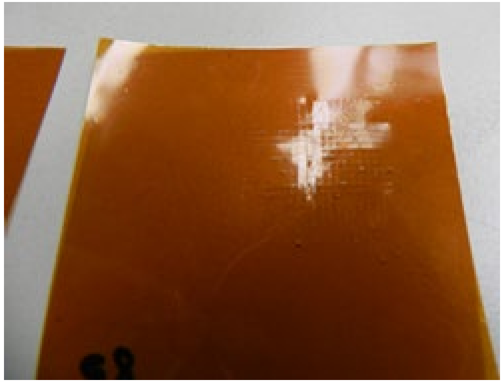
Wipe test

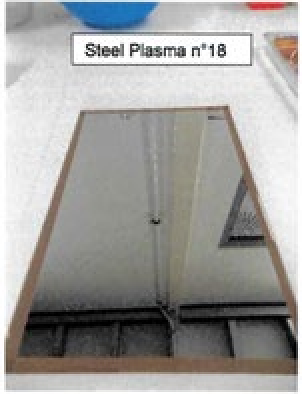


Adhesion test



Before 2nd salt spray:

Corrosion test



Ageing test

OUTCOMES NBACTSPACE

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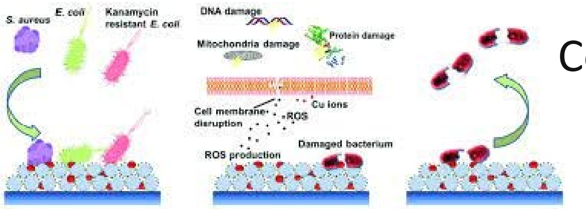
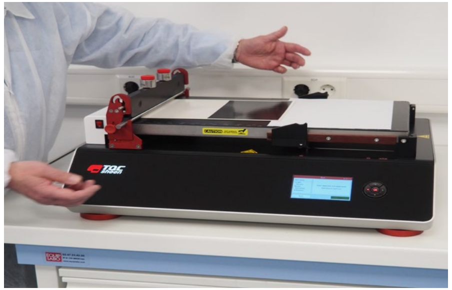
1) **Project NBactSpace 2**:

Work Assumption 1 => material improvement

By combining sol-gel, powder processing and wet deposition, we want to produce all pathogen-resistant surfaces

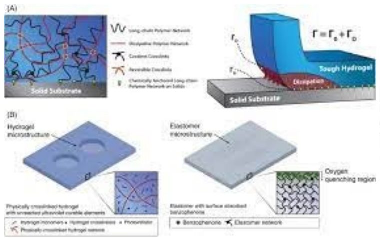


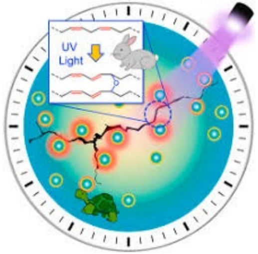
Contact killing approach



Work Assumption 2 => process improvement

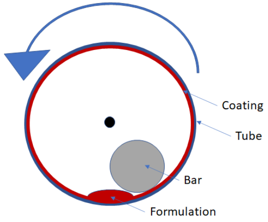
By using cleaner and more efficient processes, we want to decrease the environmental impact/cost/time of the adhesion promotion and curing steps.

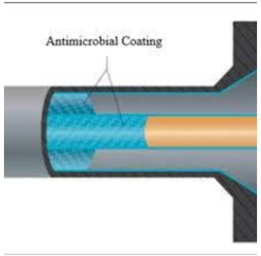




Work Assumption 3 => Deposition on inner wall of tubes

Develop a coating process on inner tube wall based on bar deposition. Validate the coatings with this novel set-up





OUTCOMES NBACTSPACE

2) **Project Euro DIGREENAC:**

- **Call – HORIZON-CL4-2022-RESILIENCE-01-23: Safe- and sustainable-by-design organic and hybrid coatings (RIA)**

WP1 →
- Development of organic and hybrid coatings, safe- and sustainable-by-design production strategies with enhanced functionality

WP3-WP4-WP5 →
- A set of computational tools (including first-principles-based, data-driven, physics based and hazard, transport and fate models) to be used for supporting Safe- and Sustainable- by Design of materials

WP1-WP2-WP4 →
- At least 2 novel materials (including bio-based ones) assessed in terms of their performance (function), human and environmental hazards (end-points determined based on the application areas) as well as their carbon and water footprints, recovery and recyclability, and overall environmental impact (LCA).

WP6 →
- Enhance the social acceptance of the new developed materials by evidence basis compiled for consumer attitudes towards, and willingness to pay for, products that are less harmful to the environment, are sustainable, low carbon etc.;

WP4 →
- Certification programme (or equivalents) for sustainable containing products, along the whole value-chain

OUTCOMES NBACTSPACE

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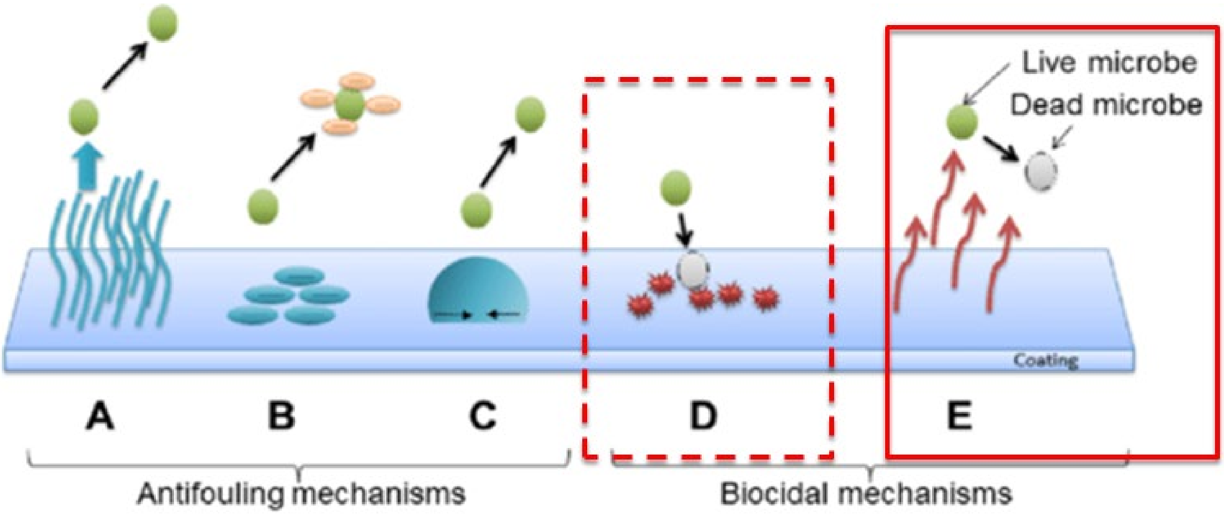
3) 2 **Patents NbactSpace submitted March 2022**



4) 2 **papers NbactSpace submitted in 2022**

=> WP2+WP3

=> WP4-WP5