



pioneering bio || intelligence
for a healthier and sustainable future.



Machine Learning-Supported Development of Safe-and-Sustainable-by-Design Biopolymer-Based Antimicrobial Coatings: Lessons from NOVA

Nihal Engin Vrana, SPARTHA Medical, France

UPREME × TRIPLE-A-COAT Joint Workshop, Ghent, Belgium

SPARTHA Medical

Headquarters: Campus Nextmed 2 Rue Marie Hamm Strasbourg/France

Laboratories: CRBS 1 Rue Eugene Boeckel Strasbourg/France

<https://sparthamedical.eu/>

Contact: Nihal Engin Vrana, evrana@sparthamedical.eu

NOVA is a comprehensive approach to antimicrobial coating development

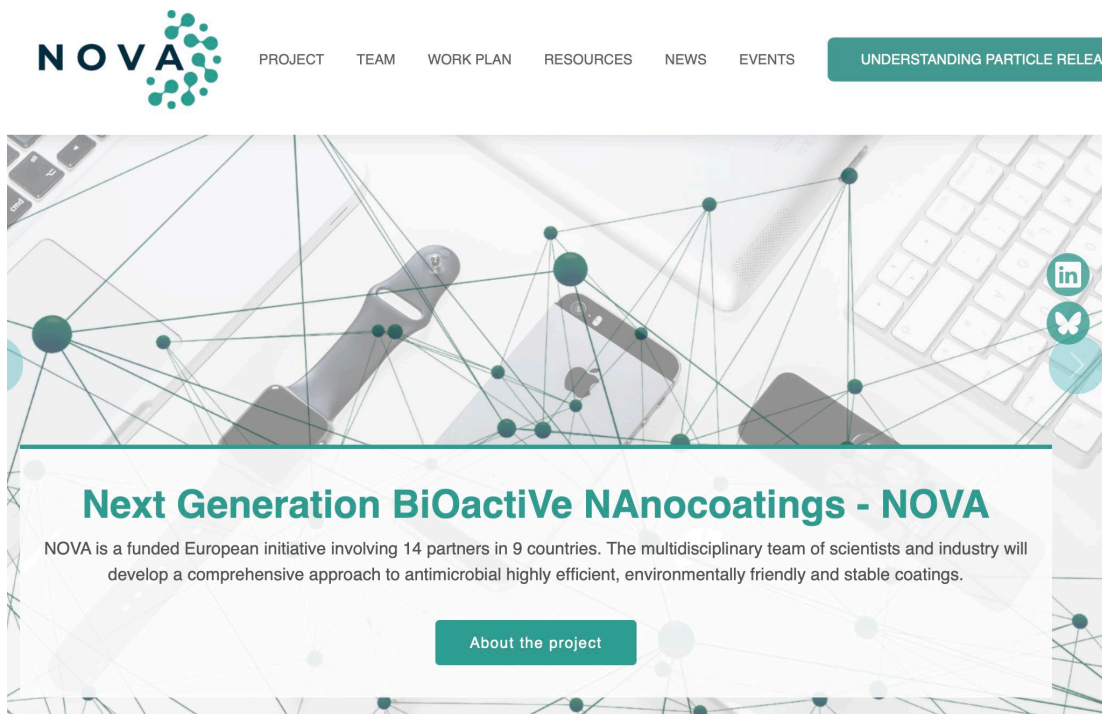
Expected Result: high efficiency, eco-friendly, stable coatings

Nova – in a nutshell

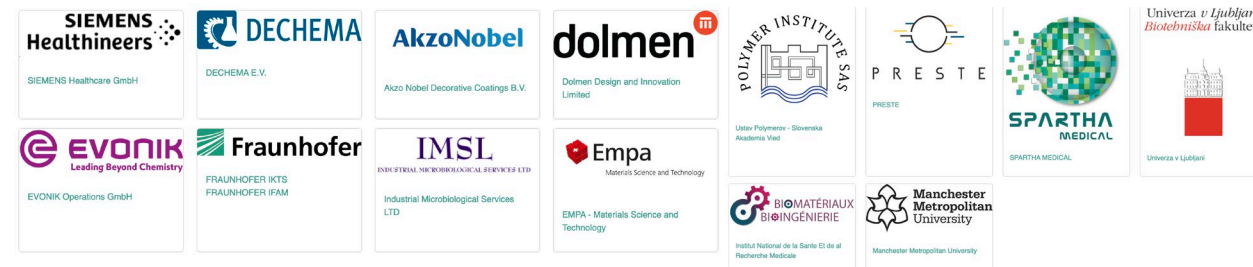
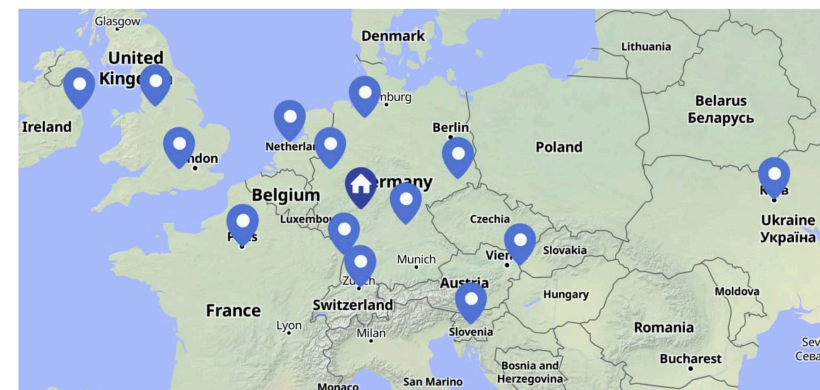


NOVA project (Horizon Europe)

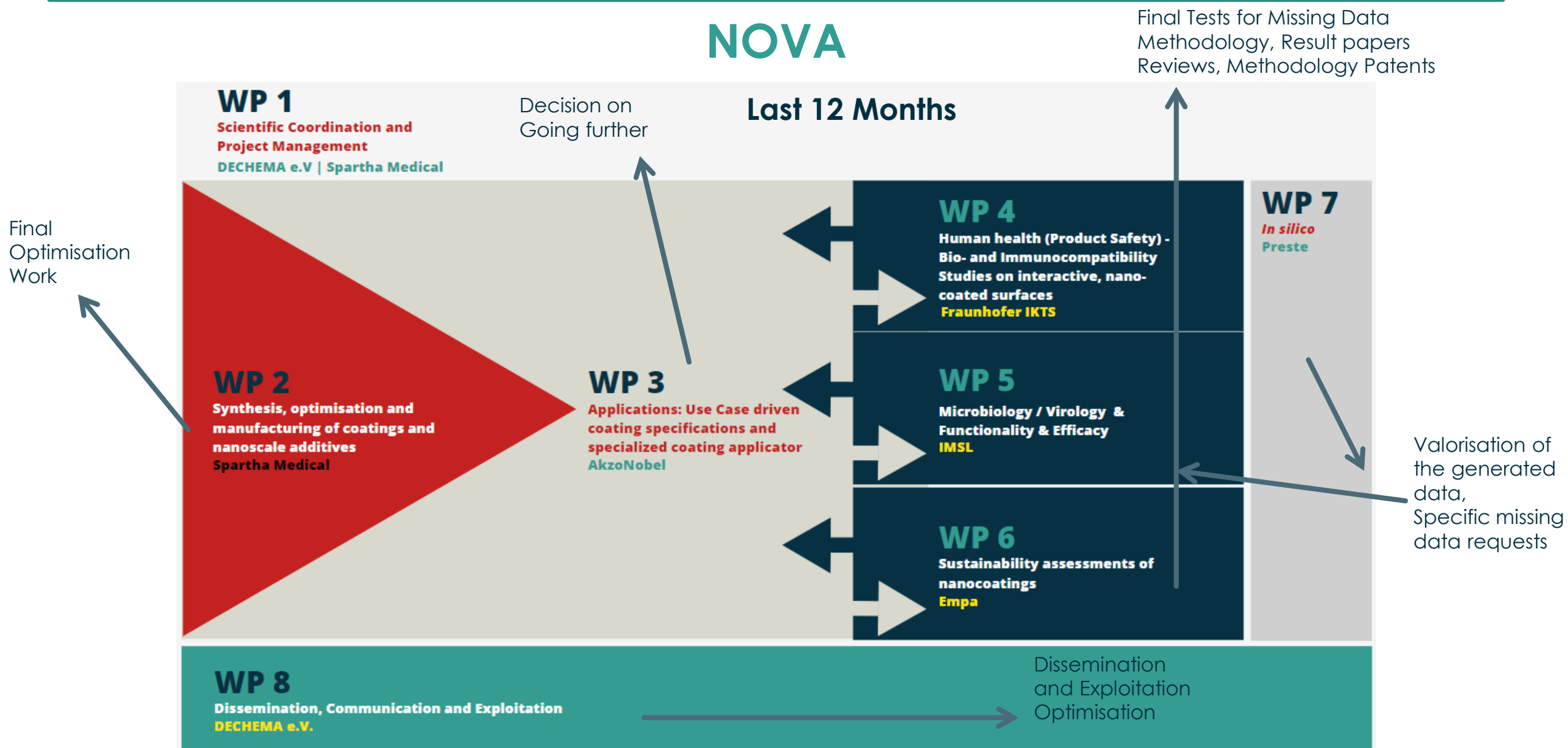
General Textile Coatings with Additional Anti-Odor Properties which is Safe and Sustainable by Design



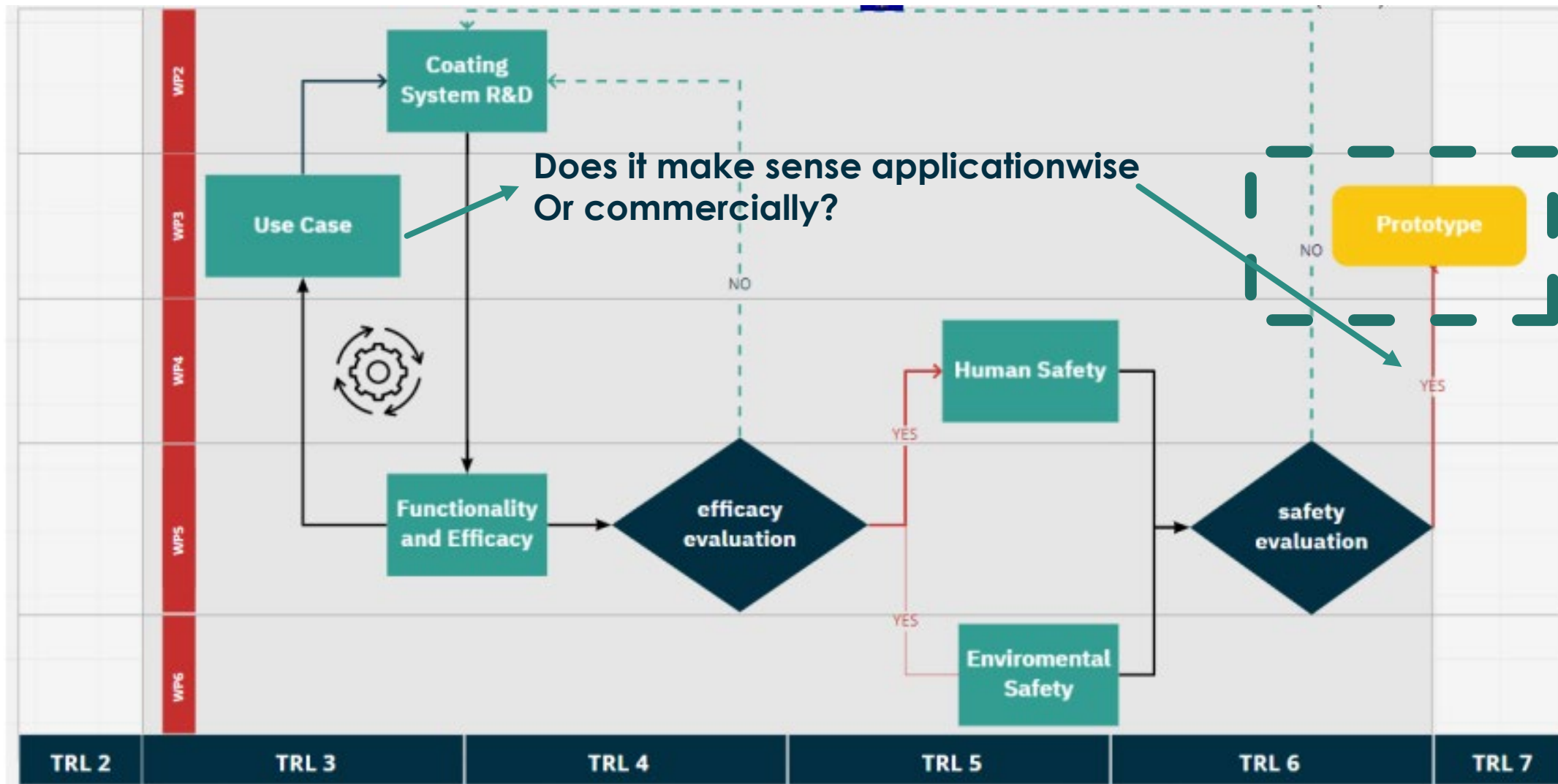
Fourteen partners in nine different countries



Funded by the European Commission, the Swiss State Secretariat for Education and the UK Research and Innovation with **€7.5 million**



NOVA - The workflow Positioning

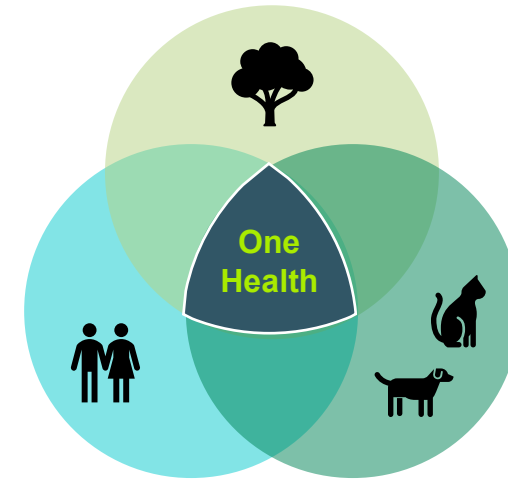


A OneHealth approach for a sustainable technology

An holistic view of Health

Human, animal and environmental health are interconnected and interdependent

Spartha and its versatile active surfaces can lower the use of antibiotics in various sectors, from the hospital to the veterinary clinic, and their release into the environment.



Sustainable Development Goals (SDG)

The UN global guidelines for the transition towards sustainable development

At Spartha, we have selected 5 SDGs on which our technology and business will have **the most impact and reach**



Safe-and-sustainable-by-Design (SSbD)

The EU pre-market framework to conciliate human and environmental safety

- Hazard assessment
- Human health and safety during production
- Human health and environment aspects in use phase
- Environmental sustainability assessment
- Social and economic sustainability assessment

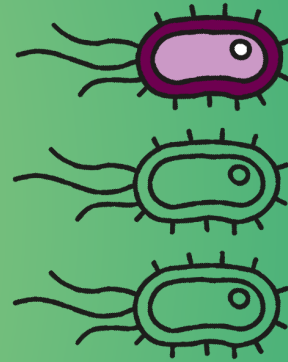
At Spartha, **we integrate this framework into our product development**, partnering with multiple experts within ongoing European projects (**NOVA & Toxbox**)

hospital-acquired infections (HAIs) & antimicrobial resistance (AMR)

increasing threats to human health ...

10% of hospitalized patients are affected by at least one HAI worldwide

leading to prolonged hospital stays, long-term disabilities, increased resistance to antimicrobials and unnecessary deaths



1 in 3 bacteria associated with HAIs is resistant to antibiotics

1.15 million

global deaths, directly caused by AMR in 2022

... and important economic burdens.

€7 billions

annual direct cost of HAIs in the EU
corresponding to 16 million extra hospital days

\$1-3.4 trillions

global GDP losses per year by 2030 due to AMR

\$28-45 billions

annual direct cost of HAIs in the USA

1.1-3.8%

global GDP loss by 2050 due to AMR

at least 20% of those infections are estimated to be preventable, particularly with improved infection control.

Spartha, by lowering infection rates, helps reduce antibiotic dependence, combat resistance, and cut healthcare costs.

The problem - examples

Case 1



F., Woman, 63

Shoulder implant surgery following an accident

Implant gets infected, revision surgery needed

- Excessive pain, edema, limited mobility
- Second implant is also infected (50% higher risk of infection on revision surgery statistically)
- Shoulder is fused limiting mobility
- Significant added expense, quality of life issues

#Implant infection

Case 2



D., Man, 46

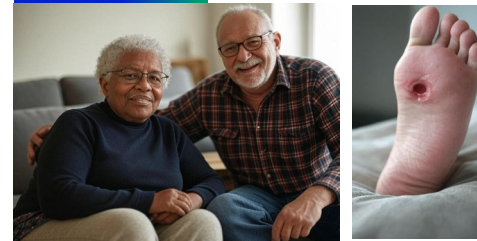
Hernia surgery utilizing a mesh implant

Mesh and surgical site get infected

- Mesh needs to be removed, and the site debrided
- Hernia still needs to be secured (often with a larger implant)
- Elongated or secondary hospital stay
- Increased time to heal
- Increased surgical site pain
- Reduced mobility
- Resistance to future surgeries if needed

#Textile infection

Case 3



M.& S., 74 and 81

Type II Diabetic foot ulcer

Ulcer gets infected

- Continuous use of various antibiotics perpetuates resistant bacteria and ultimately a biofilm
- Strong odor
- Antibiotics no longer effective
- Necrotic tissue is debrided but infection continues
- Partial or total amputation necessary
- Esthetics issues
- Mobility issues

#Tissue infection

Case 4



E., 10

Car accident

Multiple traumas, burns

- Nosocomial infections during prolonged hospital stay
- Delayed healing of wounds and burns
- Persistent pain and discomfort
- Increased risk of long-term complications
- Delayed return to school
- Social interaction difficulties linked to visible after-effects

#Emergency surgery

Technology Selection and Value Proposition

Simultaneous
antimicrobial, antifungal
coating

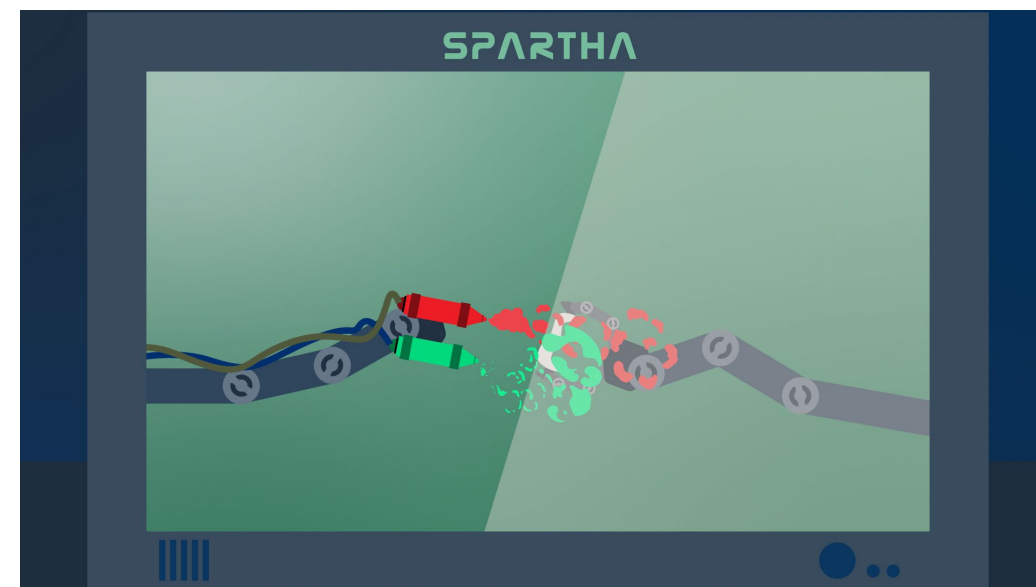
Coating
de-activates viruses
and kills bacteria on
contact

Effective against
resistant bacteria

No bacterial resistance
development against the
coating, unlike antibiotics

Can be applied to
multi-material
implants

Supra-molecular
chemistry based on
natural products, safe
for the body and the
environment



NOVA-Antimicrobial Coatings for Medical Textiles	Lower Cost	Differentiation
Broad Target	Cost Leadership	Differentiation
Narrow Target	Cost Focus	Differentiation focus (New technologies, with added features, solving an unmet need)

Active interface coatings
are made possible using
natural biopolymers and
artificial intelligence

inputs_biopolymers_characteristics

- > {biocompatibility}
- > {biodegradable}
- > {natural affinity for each other}
- > {supramolecular assembly}

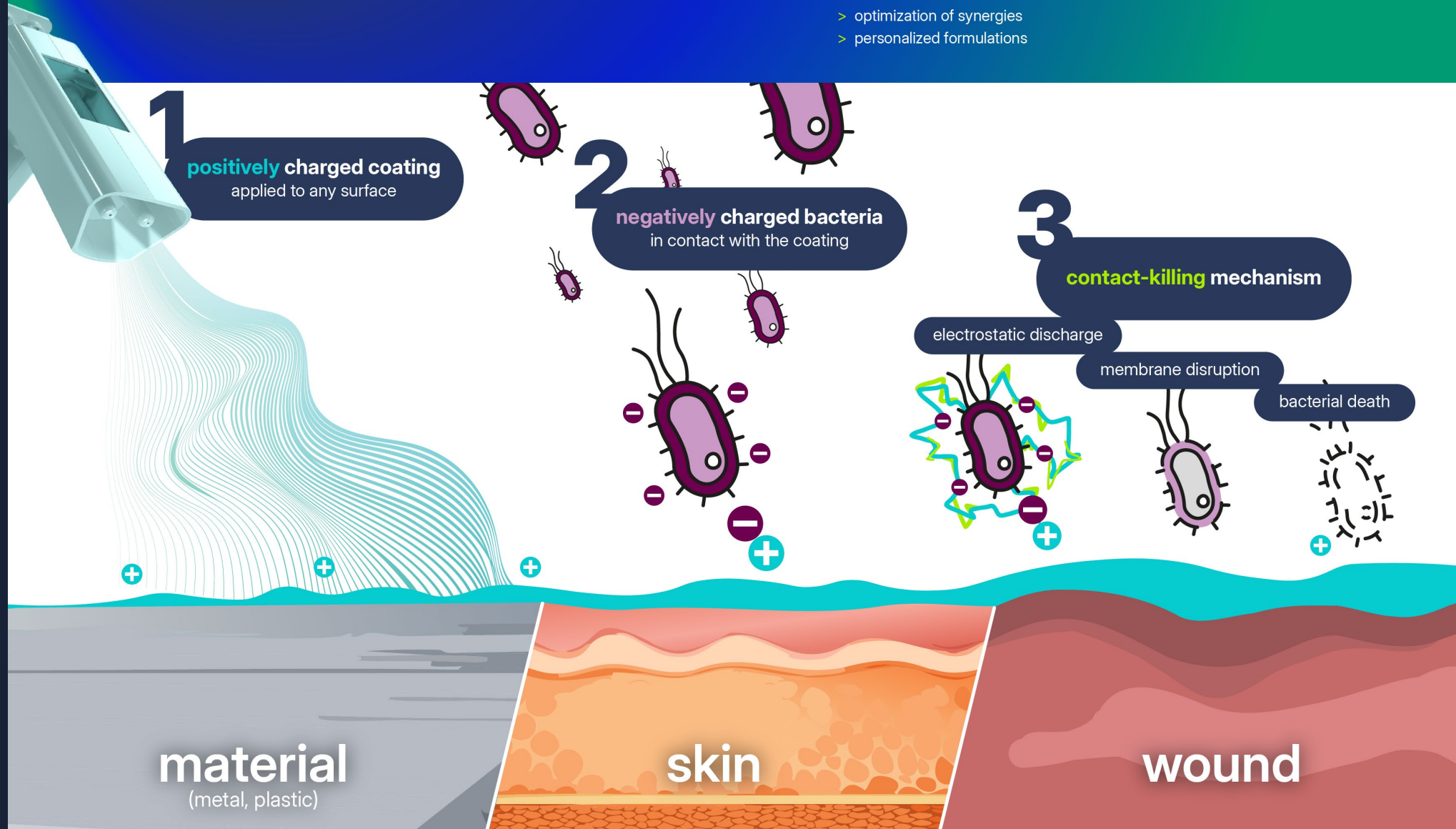


analyzing_artificial_intelligence

- > optimization of synergies
- > personalized formulations

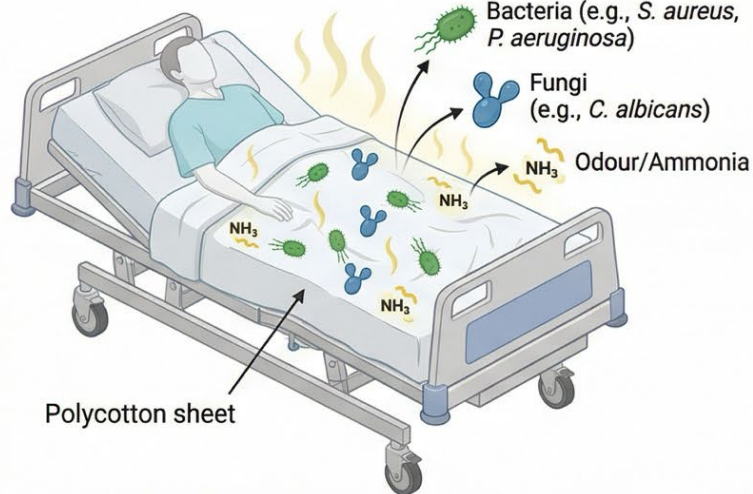
outputs_active_interface_coatings

- > antimicrobial activity: gram+ and gram-
- > no cytotoxicity
- > safe and sustainable

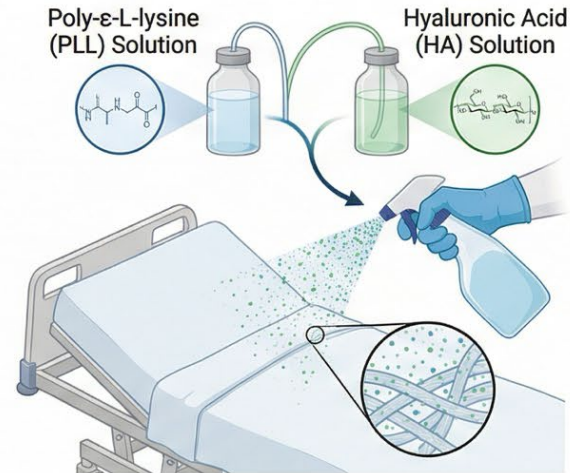


Spray coating on polycotton (bed sheet)

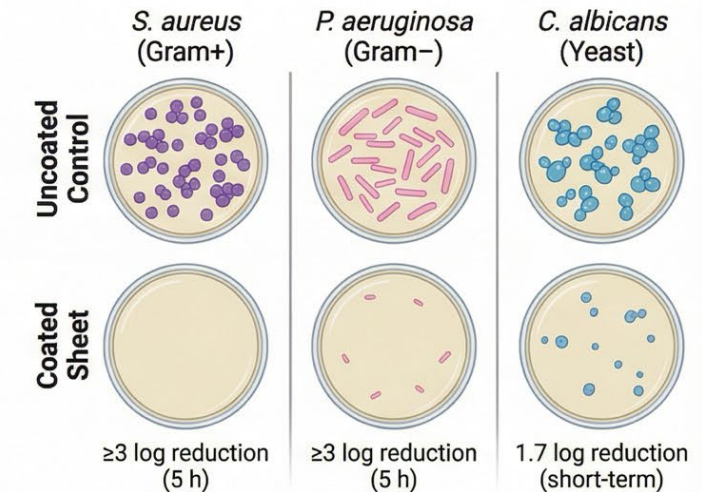
A. Hospital Bed Sheets as Microbial Reservoirs



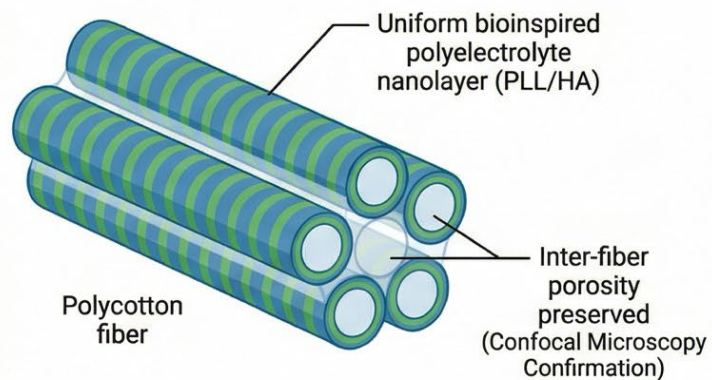
B. Spray-Coating Process



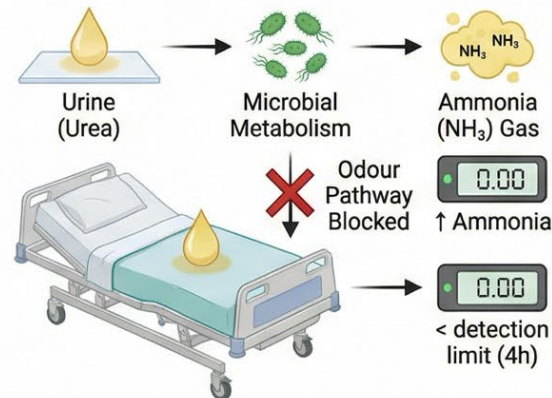
D. Antimicrobial and Anti-fungal Efficacy



C. Nanolayer Formation on Fibers



E. Anti-Odour Functionality

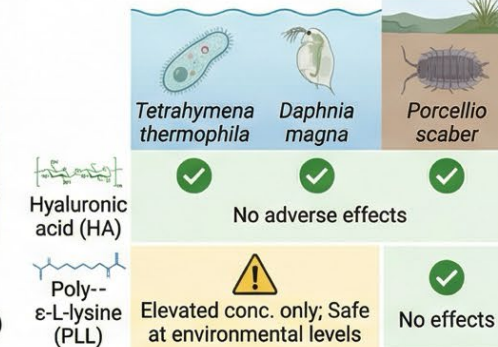


F. Biocompatibility and Environmental Safety

Skin Compatibility



Ecological Safety



Spray-applied bioinspired nanocoatings give hospital bed sheets durable, safe, and practical antimicrobial and anti-odour protection—supporting improved hygiene, patient comfort, and sustainability.

Portable spray device



For cosmetic: hair spray

For hospital bed sheets



Spartha Active Interfaces against Infections

Supramolecular Biopolymer Coatings with inherent properties which can be loaded with other active molecules



Advantages

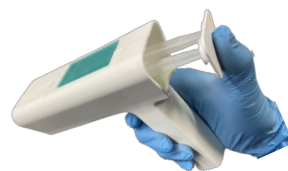
Can be applied to complex surfaces including living tissues and medical devices (Wound, Implant, Medical devices in contact with body, Skin, Medical Device Packaging)

Completely biodegradable

Self-assembly based mechanism enables applying two separate product groups

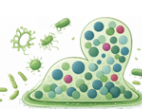
Direct Spraying to the wound

Improved mobility and pain tolerance,
potential healing product



Challenges

Biofilm formation risk



Antibiotics resistance



Negative impacts

Diabetic foot ulcer



Deep wounds



Heart pacemaker



Dental implant

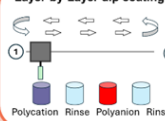


Orthopedic implant



Our solution – Polyelectrolyte coating

Layer-by-Layer dip coating

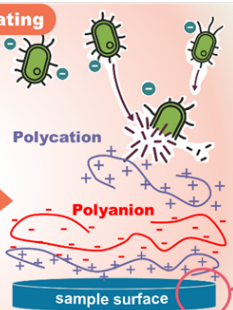


or

Layer-by-Layer spray coating

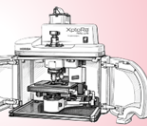


Safe and sustainable by design assessment



Coating characterization

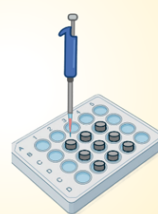
FIB-SEM microscope



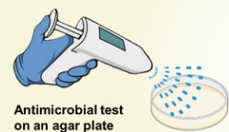
Raman spectroscopy

in vitro cytotoxicity test

Fibroblast cell Balb/3T3

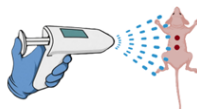


in vitro antimicrobial tests



in vivo tests – antimicrobial & inflammatory

Treatment on wounds

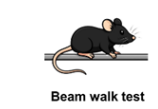


CFU counting

Bioluminescent imaging

in vivo tests – pain & motor

Treatment on the paw

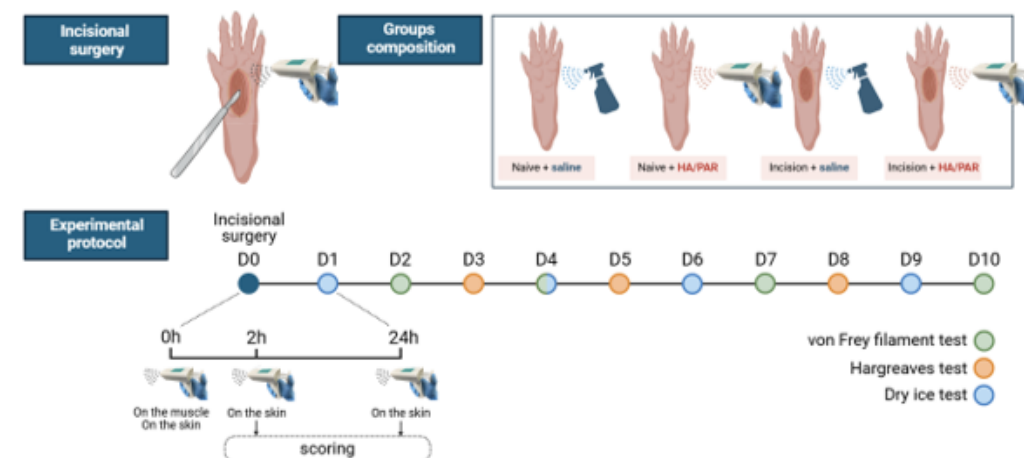


Von Frey test

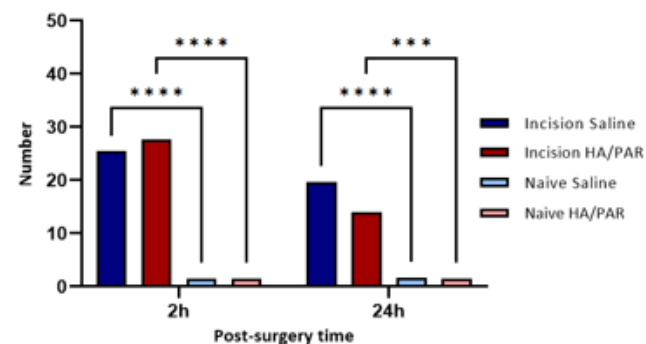
Hargreaves test

Beam walk test

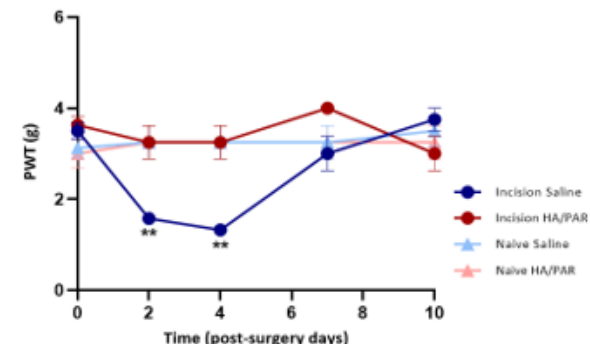
A



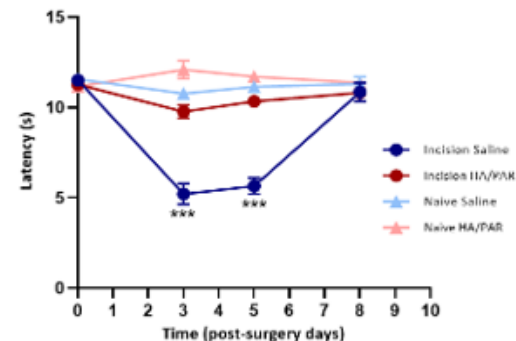
B Scoring of licking and shaking



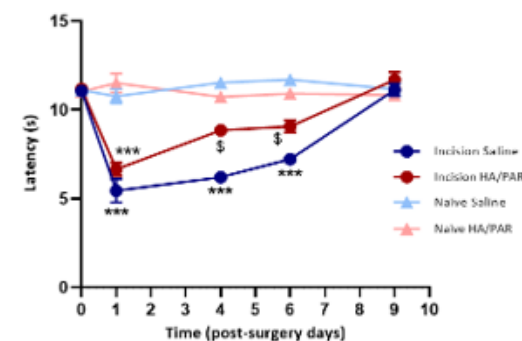
C Mechanical hypersensitivity



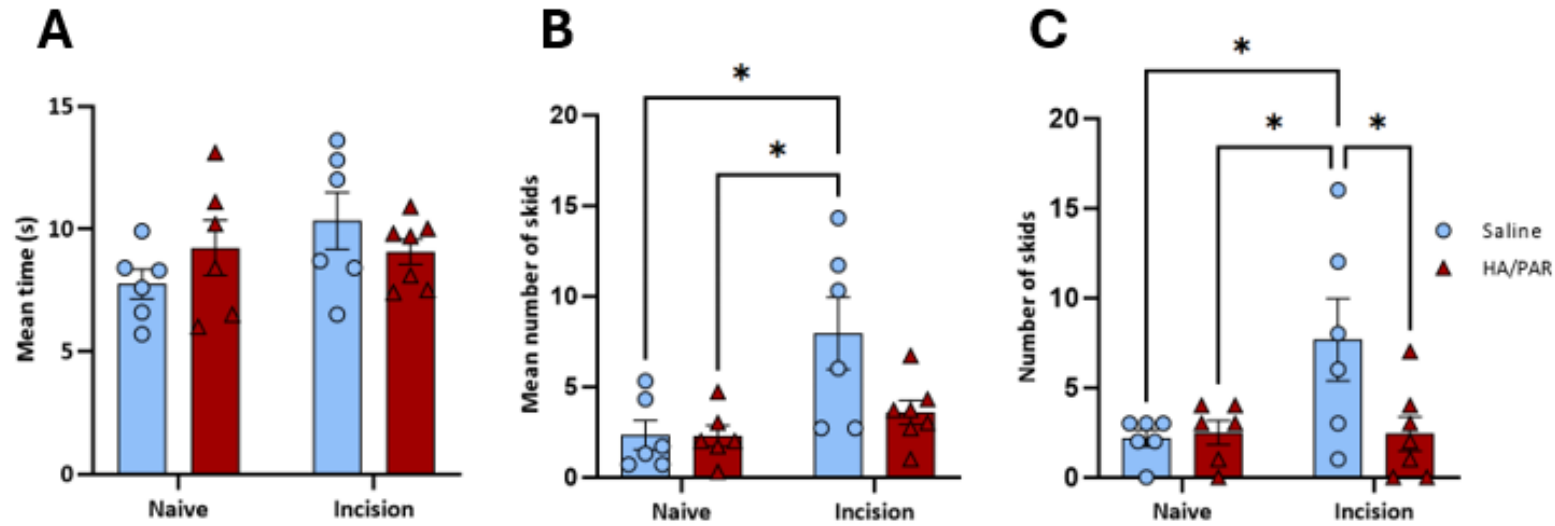
D Thermal hypersensitivity to heat



E Thermal hypersensitivity to cold



Mobility improvement after direct spraying



Patented antiviral / antimicrobial gel

based on biopolymers in collaboration with Inserm UMR 1121

Key Components

Marine carrageenans ($\lambda + \kappa$) + PEL polypeptide via ionic self-assembly

PEL Source

Natural (25-30 residues) from *Streptomyces albulus*; FDA GRAS approved

Antimicrobial Activity

Potent activity against Gram + and Gram -
Kill Speed: within 1-3 hours
Activity against *C. albicans*

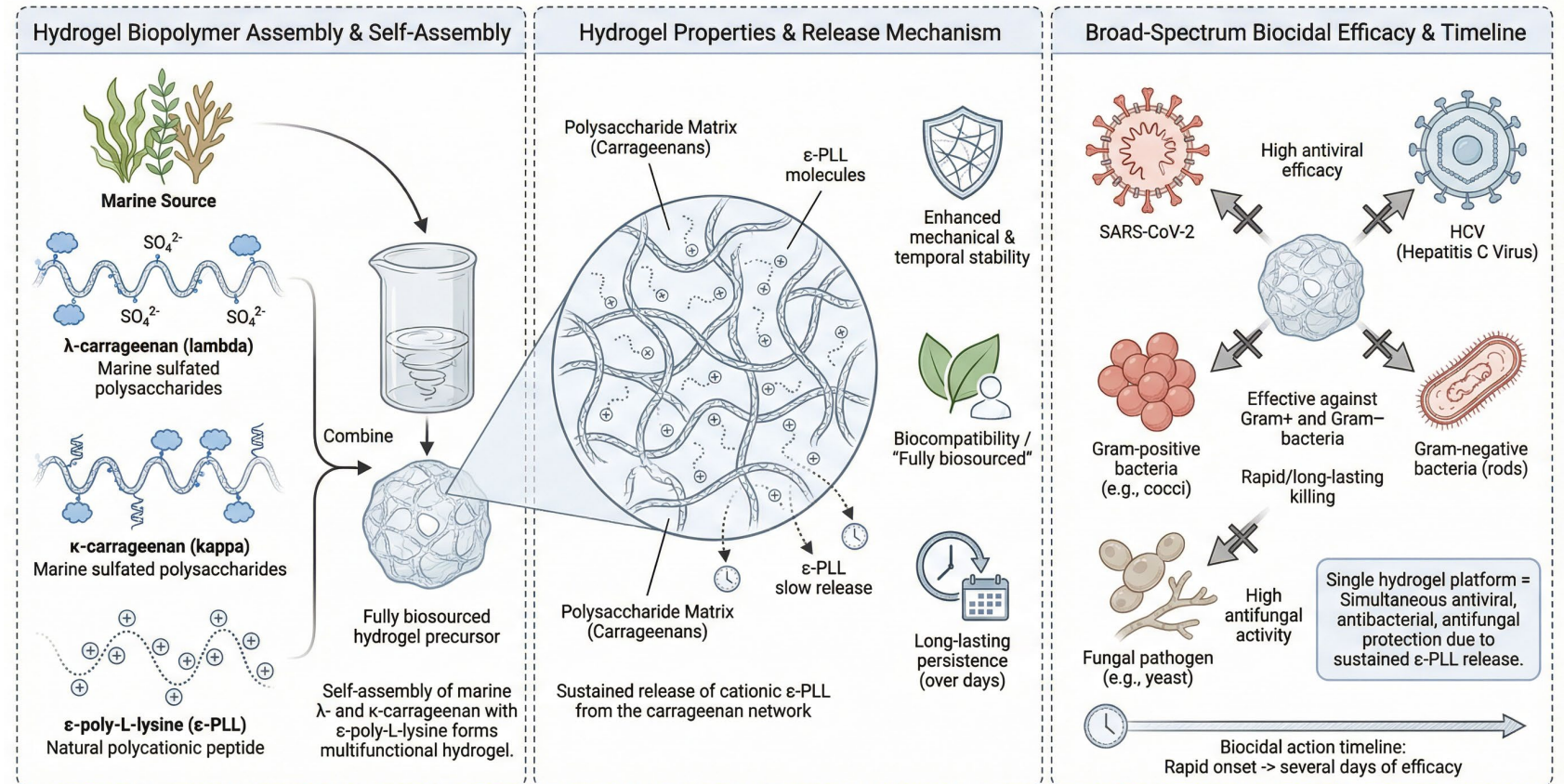
Antiviral Activity

SARS-CoV-2: 68-99% infection reduction

HCV: 25-85% infection reduction

Safety: >70% cell viability (non-cytotoxic)

Development and Multifunctional Action of Fully Biosourced Marine Biopolymer Hydrogels



Mechanism: PEL + carrageenans synergy

Work On Textile Surfaces- What worked, what didn't work?

• What Worked

- Medical textiles with direct body contact type implantable devices
- Advanced Woundcare products (Non adhesive advanced bandages for hospital use)

Current Stage: Industrialisation with a German Woundcare Company- In vitro, in vivo pre-clinical data is in place, commercialization in 2027 in USA

- Hernia Meshes

Current Stage: Testing with new provider (EMPA, IKTS, UL), the proof of concept is in place, but the original provider does not provide meshes anymore

What these coatings do: >log3 reduction Gram+ and Gram- bacteria in contact with exudate and blood

Desktop device provided by Dolmen is suitable for this kind of textile

Advanced Healthcare Materials

**ADVANCED
HEALTHCARE
MATERIALS**
www.advhealthmat.de

RESEARCH ARTICLE OPEN ACCESS

Medical Fabrics with Non-Antibiotic, Supramolecular Antimicrobial Coatings: A Preventive Approach to Combat Biofilm Formation and Bacterial Dissemination

Adjara Diarrassouba¹ | Abdessalem Rekiki³ | Cécile Loubière² | Sabine Kuchler-Bopp²  | Lauriane Petit¹ | Cynthia Calligaro¹ | Derry Mercer⁴  | Aurore Gaudin³ | Naomi Canourgues³ | Emilie Adicéam³ | Benoit Beitz³ | Jeremy Welsch⁴ | Annabelle Vigué⁵ | Markus j. Kettel⁶  | Michael Karl⁶ | Chloé Guilbaud-Chéreau¹ | Philippe Laval^{1,2}  | Nihal Engin Vrana¹  | Skander Hathroubi¹ 

¹SPARTHA Medical SAS Microbiology R&D laboratory, CRBS, Strasbourg, France | ²INSERM/Université De Strasbourg, UMR_S1121, Strasbourg, France |

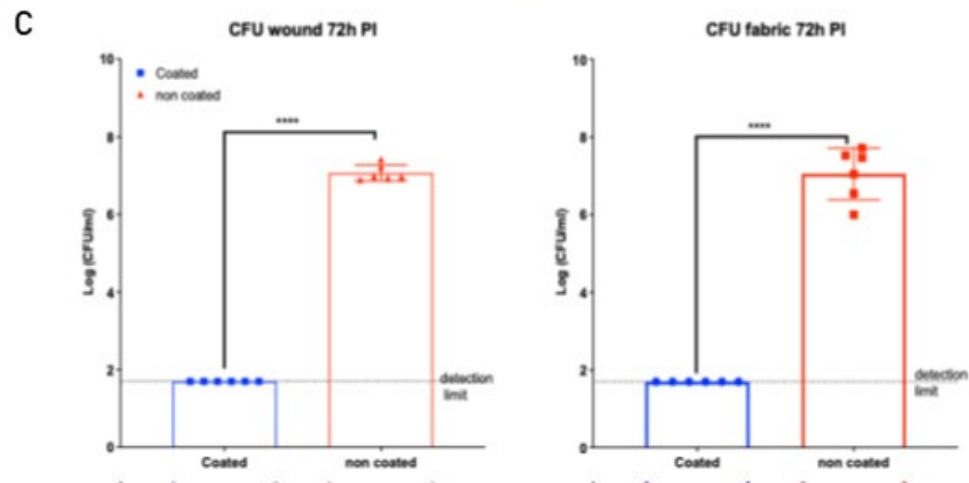
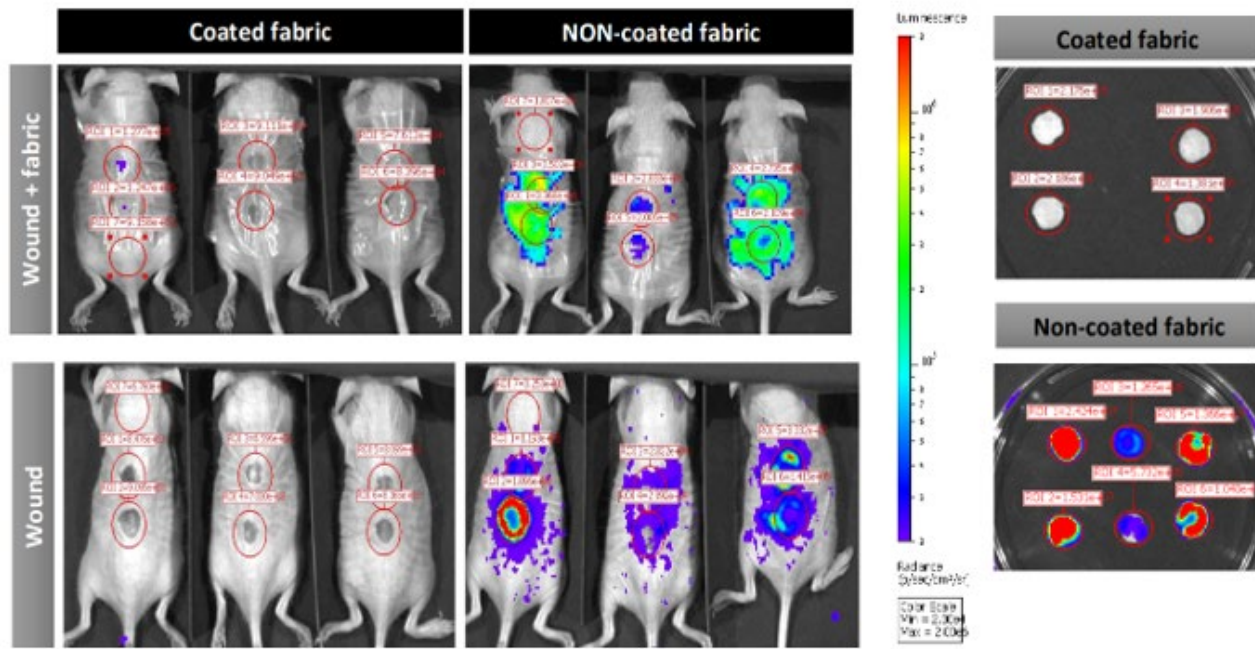
³BIOASTER Research Institute, 28 rue du Docteur Roux, Paris, France | ⁴BIOASTER Research Institute, 40 avenue Tony Garnier, Lyon, France | ⁵Paul Hartmann SAS, Lièpvre, France | ⁶Paul Hartmann AG, Paul Hartmann Str. 12, Heidenheim, Germany

Correspondence: Nihal Engin Vrana (evrana@sparthamedical.eu) | Skander Hathroubi (shathrou@sparthamedical.eu)

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Keywords: antimicrobial peptides | biocompatibility | biofilm prevention | biopolymers | coating | hemocompatibility | medical device | supramolecular assembly | wound infection

A diagram of a white mouse with a red wound on its back. The wound is labeled 'wound' with a line pointing to it. The mouse is labeled 'mouse' with a line pointing to its head.



Work On Textile Surfaces- Final Steps

Medical textiles with direct body contact type implantable devices

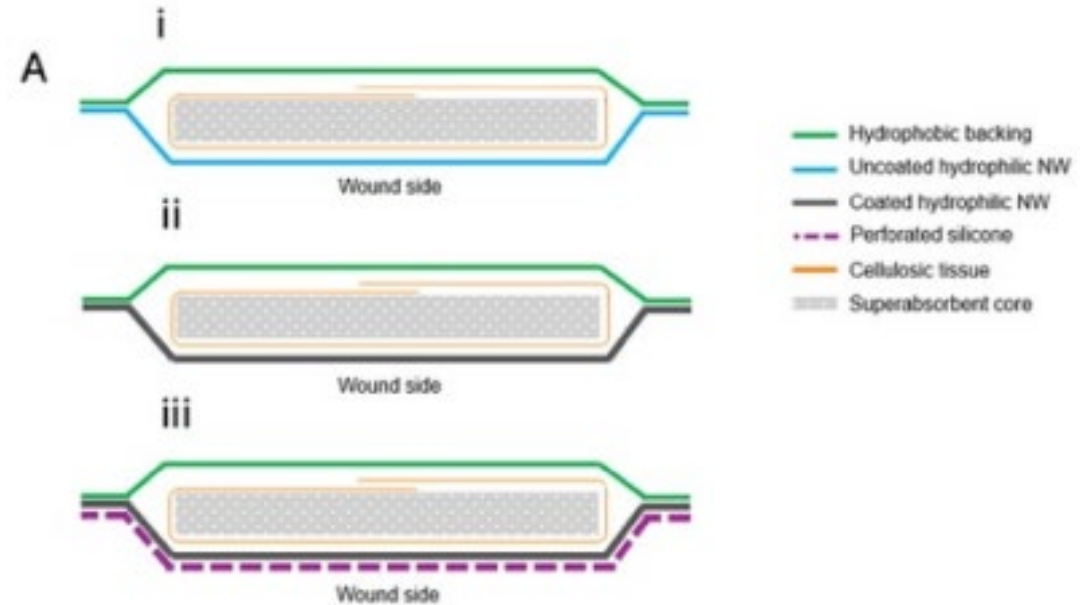
- Advanced Woundcare products (Non adhesive advanced bandages for hospital use)

Additional Work: Full prototypes

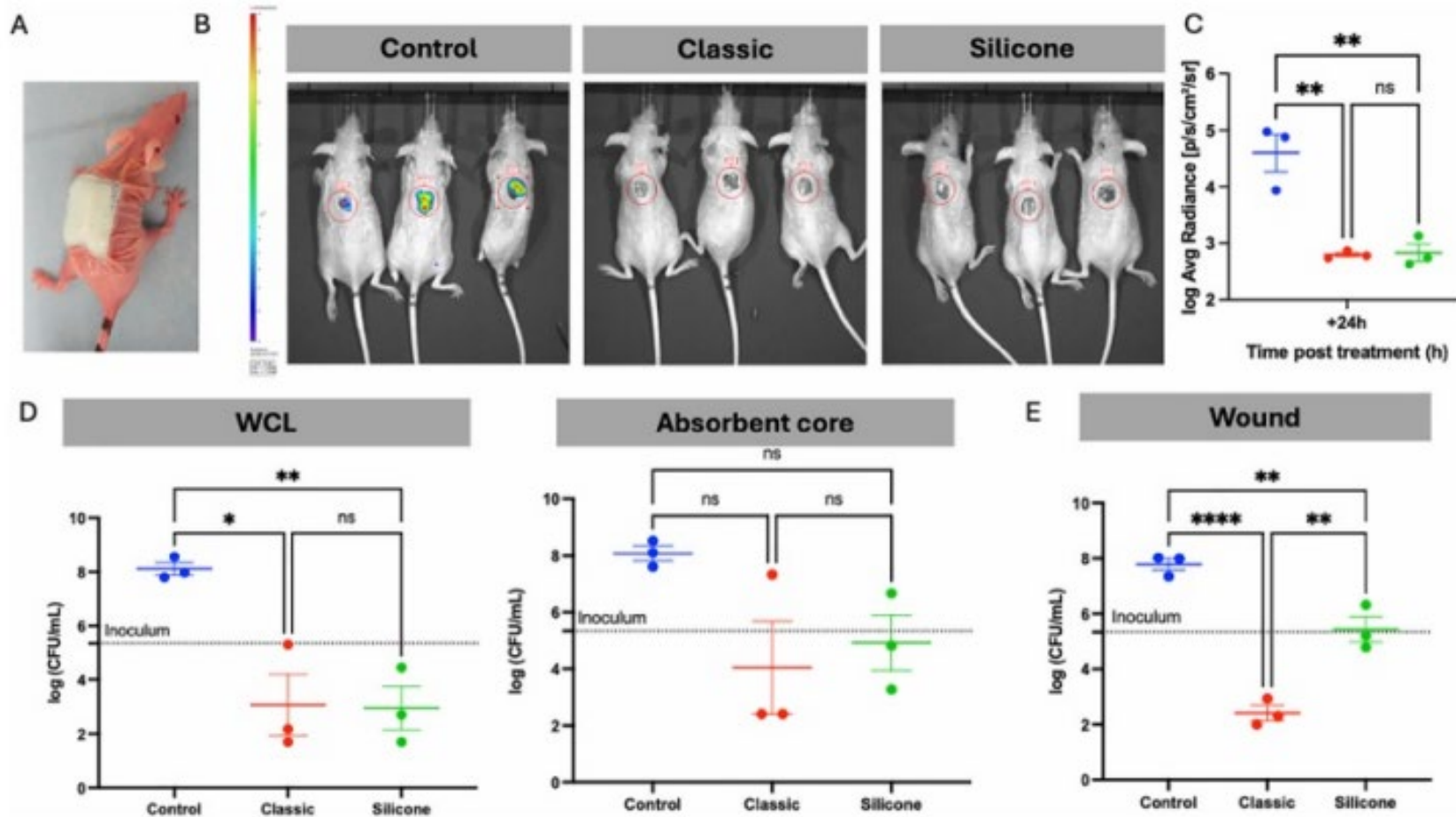
- Hernia Meshes

Updates from WP5

Desktop device/Spray device:
Dolmen Updates

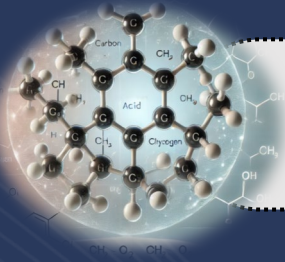


Woundcare product IV-In vivo



How do we customise our formulations?

Innovations based on scientific know-how and *in silico* modelling

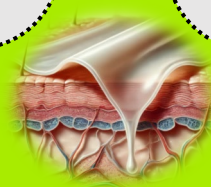


Biopolymer catalogue (Polyions)

Different characteristics, properties and interactions discovered after 20+ years of research

Artificial Intelligence

In-house AI modelling for new solutions tailored to the expected outcome



Innovative active interfaces

Assembly of two or more components for a personalised solution to meet our customers' needs as closely as possible, while respecting regulatory and sustainability practices

Microbiology Expertise

Testing

Bacteria-sourced polymers

Coating Device Development

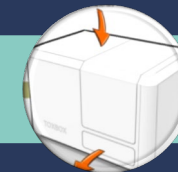
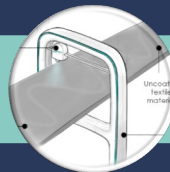
Desktop devices

Handheld devices

Real Life Mimicking Testing

Product-specific test method development

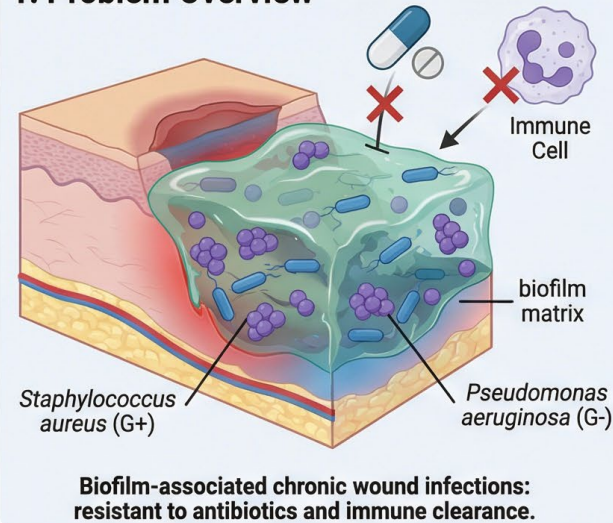
Use case specific test method development



Artificial intelligence-guided detection of short peptide motifs

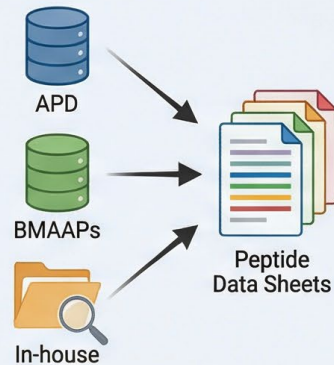
for development of potent antibiofilm peptides

1. Problem Overview



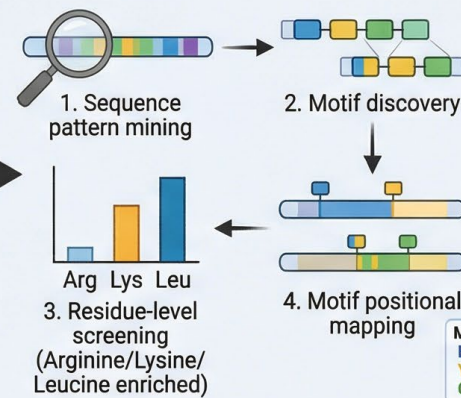
2. Integrated AI-Guided Workflow

A. Data Integration



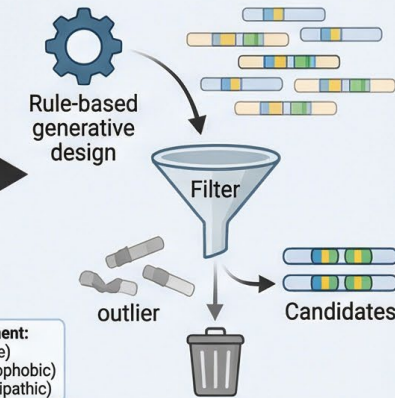
Peptide data harmonization:
physicochemical & structural descriptors,
microbial target, activity levels

B. Computational Analysis



AI-driven discovery of antibiofilm activity patterns

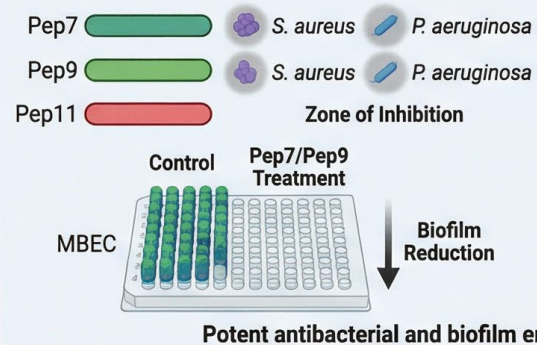
C. Peptide Design & Filtering



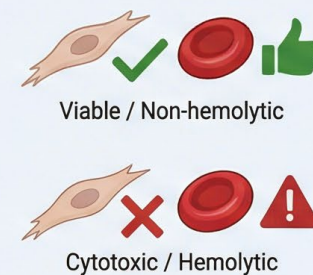
Motif-guided sequence generation;
filtering by physicochemical constraints

3. Experimental Validation

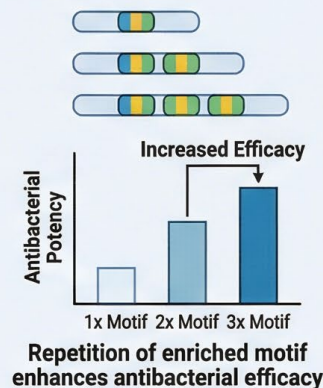
A. Antibacterial & Biofilm Disruption Assays



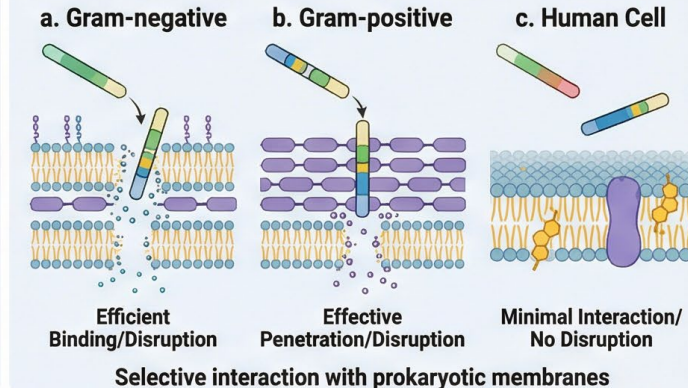
B. Biocompatibility Testing



4. Motif Functional Validation



5. Membrane Interaction



6. Clinical Outlook



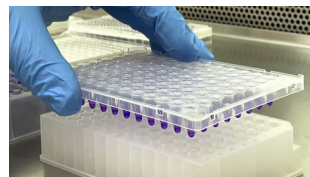
Towards effective, safe topical antibiofilm therapeutics for chronic infections. Combating antibiotic resistance.

Anti-bacterial Activity

Peptides	<i>P. aeruginosa</i>		<i>S. aureus</i>	
	MIC $\mu\text{g/mL}$	MBC $\mu\text{g/mL}$	MIC $\mu\text{g/mL}$	MBC $\mu\text{g/mL}$
Pep 1	>150	>150	>150	>150
Pep 2	>150	>150	>150	>150
Pep 3	>150	>150	>150	>150
Pep 4	9-37	19-37	150	150
Pep 5	19-37	37	19-37	37
Pep 6	37-150	75-150	19-37	37-150
Pep 7	9-18	9-18	19-37	19-37
Pep 8	>150	>150	>150	>150
Pep 9	9-18	9-18	37-75	37-75
Pep 10	150	150	150	150
Pep 11	5-9	5-9	9-37	9-37
Pep 12	75-150	75-150	37-75	75

From the 12 selected peptides.. All successfully synthesized.. 7 exhibited potent antibacterial activity.. 3 selected for antibiofilm activity..

Anti-biofilm Activity



MBEC assays

Cytocompatible

Hemocompatible



Human Skin, An **Extraordinary** Interface



PROTECTION

First line of defense against the world.



COMMUNICATION

A complex network of signals.



SENSING

Perceiving and adapting in real time.



HEALING

Designed to restore and regenerate.

Nature's most advanced interface.

Our inspiration. Our blueprint.



COMPLEX BY NATURE

Dynamic. Intelligent.
Indispensable.

FRAGILE BY CHOICE

Easily compromised.
Hard to restore.

OUR PURPOSE

To protect, respect and
empower this natural
extraordinary interface.



Devices Are **Passive**

Nature created
active interfaces.
Devices remain
passive.



PASSIVE SURFACES DRIVE:



INFECTION
RISK



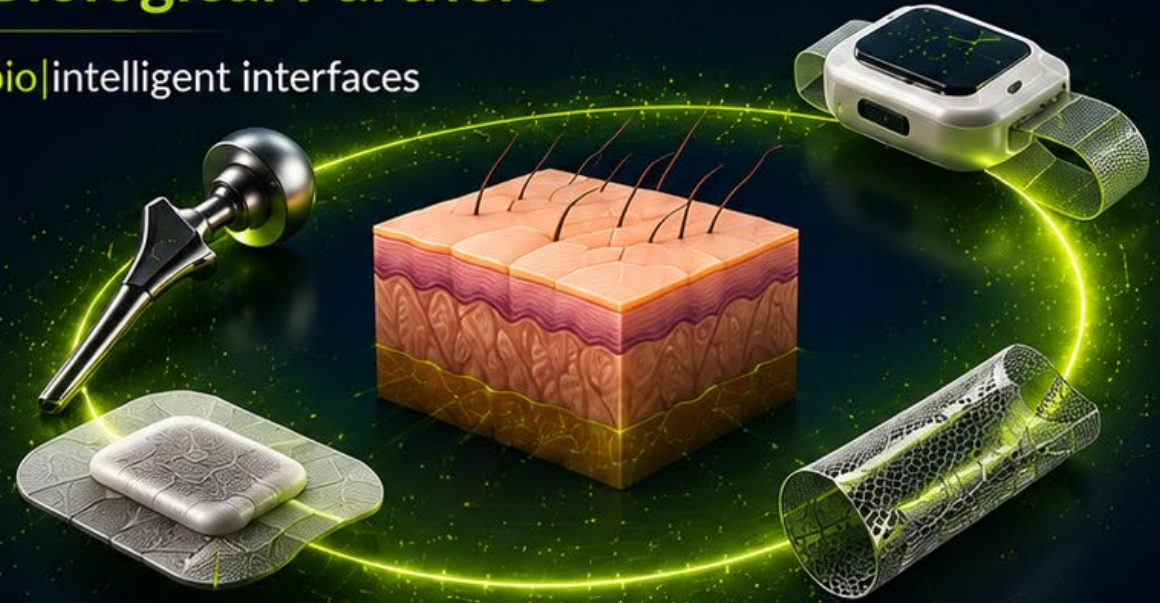
INFLAMMATION



CONTAMINATION

Spartha Transforms Materials Into **Biological Partners**

bio|intelligent interfaces



PROTECTS
against infection



ADAPTS
to the body



WORKS ACROSS
tissues & devices



MADE FOR LIFE
biocompatible

Expansion of the Current Activities and Future Outlook

- Other sectors with infection problems

Hospitals



Surgical use

Chronic wound treatment

Nursing home & other long-term care facilities

Nurses, orderlies, medical auxiliaries



Veterinary



Consumer, home settings



Sexually Transmitted Infections (STIs)

On-site emergencies, paramedics



Food packaging

02

So where were we able to sell it?
**Technology creates possibility—
 not necessarily a market.**



**Technical success ≠
 a viable entry market**

It assumes we already understand
 what the meaningful market is.

WHAT TECHNOLOGY CAN DO



Works in the lab



Safe & reliable



Scalable



High performance

CREATES POSSIBILITY

We solved a problem technically.
 Many applications become possible.



≠

BUT NOT ALL POSSIBILITIES ARE MARKETS



Mistaking being useful with being needed
 We build for problems that don't motivate anyone
 to change or to pay.



Technical success as the main aim
 A better technology is not a business strategy.
 It's only an input.



Not focusing on economics of different markets
 Will anyone pay? At what price? At what scale?
 With what margin?



Too many paths, no clear choice
 We spread across everything that could work,
 instead of what should work.



Invisible to conversion to recurrent revenues
 One-off projects don't build a company.
 Repeatability and retention do.

THE RESULT



- ✗ Scattered teams
- ✗ Diluted resources
- ✗ Slow progress
- ✗ Higher burn
- ✗ Uncertain outcomes
- ✗ Strategic drift

**Activity
 ≠
 Strategy.**



**Choose the right market.
 Then build the right product.**



Understand real
 customer needs



Evaluate economics
 of the market



Focus. Prioritize.
 Win.

IS IT REALLY AN OPPORTUNITY?

Four lenses to turn technology into a viable market entry.



LOGISTICS

Can our solution/technology fit into the real world?



USER

- ✓ Fits into workflow
- ✓ Easy to use
- ✓ Behaviour change acceptable



BUYER

- ✓ Budget impact
- ✓ Procurement process
- ✓ Decision criteria aligned



PRODUCTION

- ✓ Manufacturable
- ✓ Scalable
- ✓ Supply chain ready
- ✓ Cost sustainable



REGULATION

- ✓ Regulatory pathway
- ✓ Evidence requirements
- ✓ Reimbursement
- ✓ Market access



A great technology is not a great opportunity if **nobody meaningfully needs it**, the improvement **doesn't matter**, **nobody needs it now** — or the real world **cannot absorb it**.





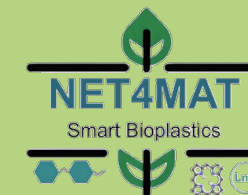
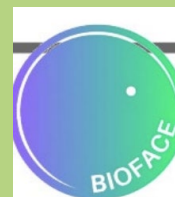
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EIC supports Spartha for its SPARTHACUS project



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Contact: Nihal Engin Vrana, evrana@sparthamedical.eu