CoE in Materials-Driven Solutions for Combating Antimicrobial Resistance (MADNESS)

Kuldeep K. Bansal[1,2], Peter Uppstu[2], Xiaoju Wang[1,3], Hongbo Zhang[1], Sébastien Lafond[4], Ivan Porres Paltor[4], Tapani Viitala[1], Carl-Eric Wilen[2], Chunlin Xu[3], Jessica Rosenholm[1]

[1] Pharmaceutical Sciences Laboratory, Faculty of Science and Engineering, Åbo Akademi University, Turku, Finland
[2] Laboratory of Molecular Science and Engineering, Faculty of Science and Engineering, Åbo Akademi University, Turku, Finland
[3] Laboratory of Natural Materials Technology, Faculty of Science and Engineering, Åbo Akademi University, Turku, Finland
[4] Information Technology, Faculty of Science and Engineering, Åbo Akademi University, Turku, Finland

INTRODUCTION

Antimicrobial resistance (AMR) poses a significant risk to public health by rendering the treatment of infectious diseases challenging or potentially unfeasible. The World Health Organization (WHO) listed AMR as one of the top 10 global health threats owing to:

- Misuse and overuse of antimicrobial drugs,
- Difficult-to-treat biofilm-forming bacteria, and
- Slow response by pharmaceutical companies in developing new antimicrobials drugs.

Thus, alternative approaches are urgently sought to combat AMR. Our Centre of Excellence (CoE) "MADNESS" at ÅAU was established to generate alternative solutions for AMR, by joining expert forces from the fields of pharmacy, materials sciences and artificial intelligence (AI).

AIM

Our aim is to create materials-centered therapeutic strategies against microbial infections with a specific emphasis on addressing AMR issues.

METHODS

- **AI-aided materials design and development:** AI-based simulation methods will be developed to reduce the design life cycle and provide extensive information on designing optimal nanomaterials with high therapeutic efficacies.
- **Woody polyphenols as inherently antimicrobial NPs:** Lignin self-assembly and the antibacterial properties of tannins will be combined in core-shell nanoparticles (NP) structures for coating on medical surfaces.
- **Sustainable and functional polymeric NPs as antimicrobial drug carriers:** Small molecules will be loaded into novel functional poly(jasmine lactone) micelles to improve therapeutic efficacy.
- **Inorganic NPs as carriers for genetic constructs:** Porous inorganic NPs such as mesoporous silica nanoparticles (MSNs) and mental-organic frameworks (MOFs) will be used to deliver mRNA or CRISPR/Cas9 as an alternative method to tackle AMR.
- **Antimicrobial medical textiles towards combinatorial AMR therapy:** Flexible cellulose nanofibers with polypyrrole nanocoating (cationic surface) will be utilized to fight biofilm infections.
- **Functional composite scaffolds for tissue regeneration:** 3D-printed polymer-based composites that release bioactive agents for difficult-to-treat, even infected bone defects.
- **Implementing new real-time label-free analytical tools:** New analytical platforms based on surface plasmon resonance (SPR) will be utilized for real-time label-free measurements of bacterial adhesion and biofilm growth kinetics.

EXPECTED RESULTS

Throughout the project, we will deepen our knowledge on the impact of distinct materials on AMR. We expect to create a “toolbox” for treating infectious diseases where traditional antimicrobials are ineffective.

CONCLUSIONS

We envision to create highly specialized solutions that have great potential for practical implementation and can have an impact on the pharmaceutical industry, while creating new opportunities for entrepreneurs. In the future, we believe to aid people in managing prevalent microorganisms in a financially viable manner.

ACKNOWLEDGEMENT

The authors would like to thank Åbo Akademi University Foundation (Stiftelsen för Åbo Akademi) for funding the CoEs during 2024-2028.