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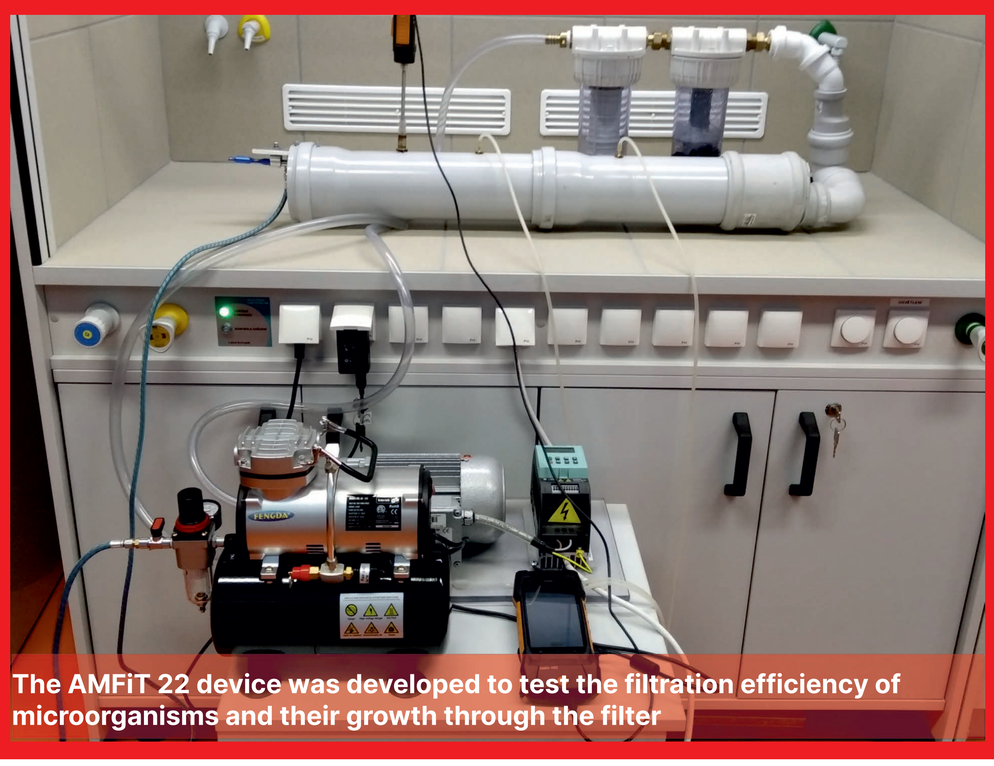
HY HI RESEARCH PROGRAMME 3 FUNCTIONALIZED NANOMATERIALS

RESEARCH ACTIVITY 1: MODIFICATION OF STRUCTURES FOR THE ELIMINATION OF HAZARDOUS SUBSTANCES

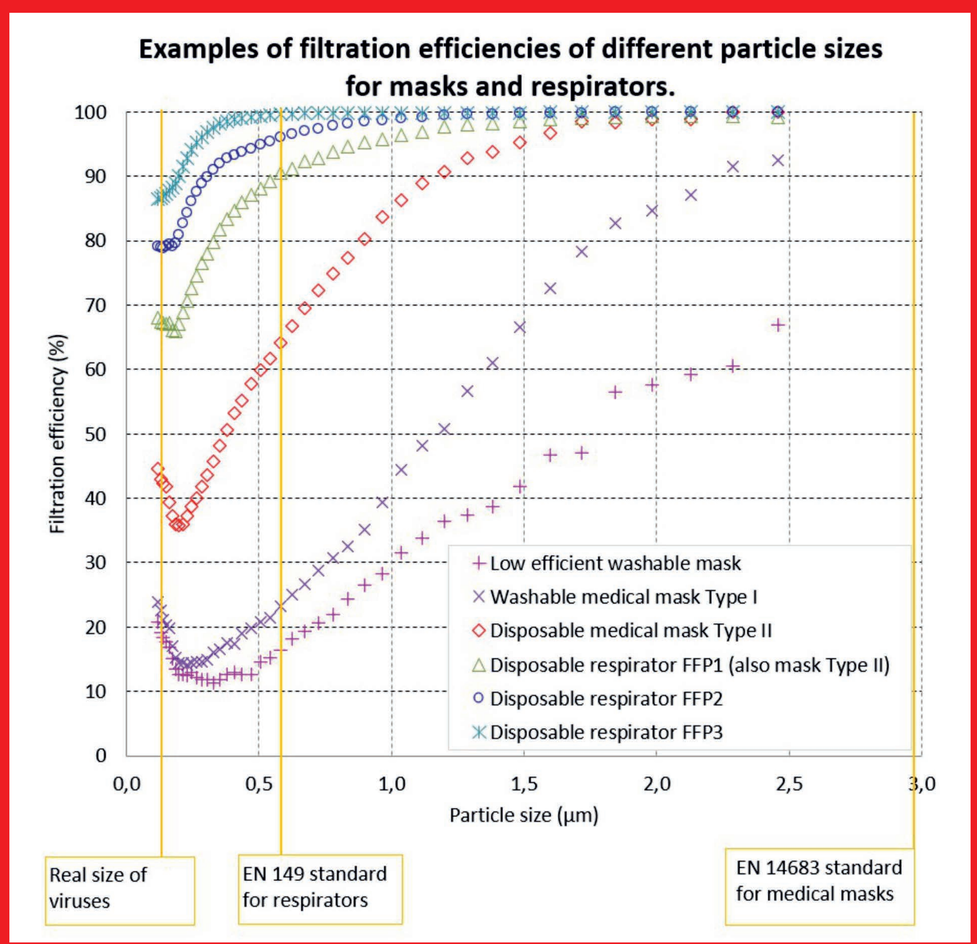
OBJECTIVES

- Development of laboratory focused on filtration and separation of gases and liquids. Development of new test methods.
- Preparation of specific porous and nanofibrous structures.
- Optimization and functionalization of the properties of nanofibrous structures, especially by surface treatment.
- Tests of prepared materials in given applications and their further development and optimization:

a) water/oil separation,
b) surface modification of nanofibrous membranes and filters,
c) air filters used against bacteria and viruses (hepa filters, respirators, masks),
d) filtration of pollutants in flue gas.



The AMFiT 22 device was developed to test the filtration efficiency of microorganisms and their growth through the filter



RESULTS AND OUTPUTS

- Publications on the use of nanofibers in water purification, water/oil separation, antimicrobial treatment of nanofiber air filters, modification of polymers with the aim of changing the separation and transport properties of nanofiber layers.
- Sample book of nanofibrous materials suitable for cleaning wastewater and industrially polluted water from microorganisms and microparticles.
- Methodology of laboratory measurement and evaluation of personal protective equipment (respirators, masks).
- Methodology for simulating the adjustment of the concentration of emissions in flue gas.

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RESEARCH PROGRAMME 3
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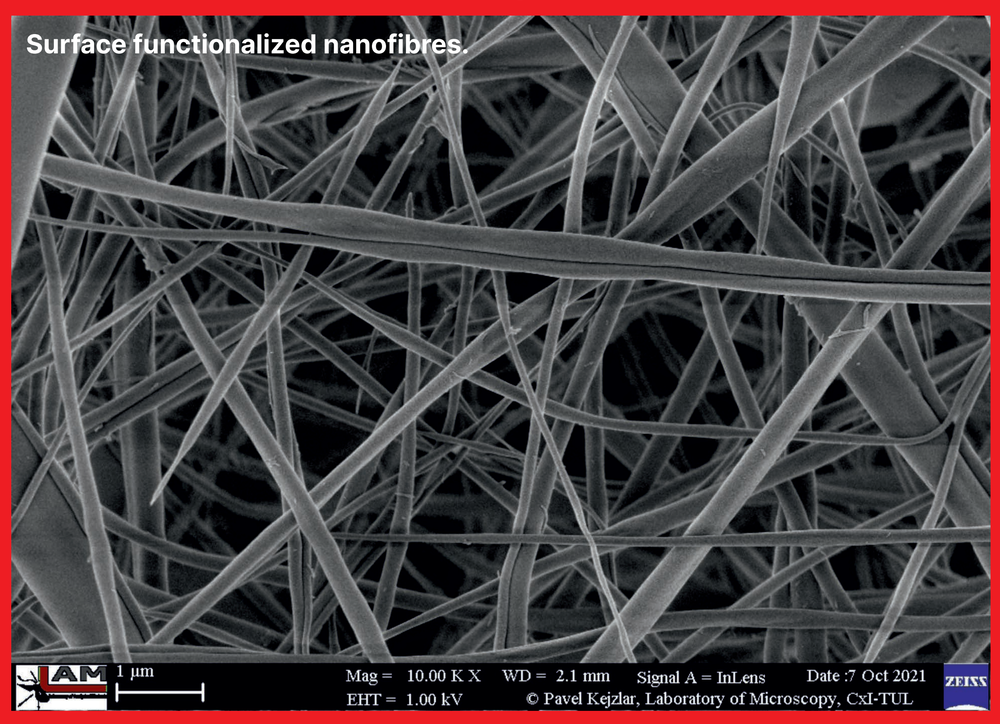
RESEARCH ACTIVITY 2:
DEVELOPMENT AND MODIFICATIONS OF NANOSTRUCTURES FOR TRANSPORT APPLICATIONS

OBJECTIVES

Research performed in this activity focuses on development and testing of materials suitable for application in medical field. Application of nanomaterials in medicine places a broad range of requirements on the material depending on the site of action, expected degradation rate and functionality.

Functionalization of the nanomaterials can be performed in order to optimize transport of active compounds into the living tissue and their stability within. The aim of this activity is to develop and functionalize nanomaterials for tissue regeneration stimulation and drug delivery and characterize them in terms of bioactivity, biocompatibility, antibacterial activity and degradation kinetics.



Surface functionalized nanofibres.

RESULTS AND OUTPUTS

Novel types of nanofibrous wound dressings, tissue engineering scaffolds and systems for enzyme conjugation, with various surface functionalities and degradation mechanisms were developed. For example silica nanofibres, which are able to promote wound healing through orthosilicic acid release upon their degradation, were functionalized with various antibacterial compounds. Their release kinetics studies confirmed ability to eliminate complex bacterial biofilm in wound within 72 hours. Biocompatibility of this system to skin, liver, kidney and intestinal tissue was confirmed in vitro. No chromosomal aberration nor haemolytic effect were found.

Human dermal fibroblasts proliferating in presence of nanofibrous dressing for 72 hours.

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RESEARCH PROGRAMME 3
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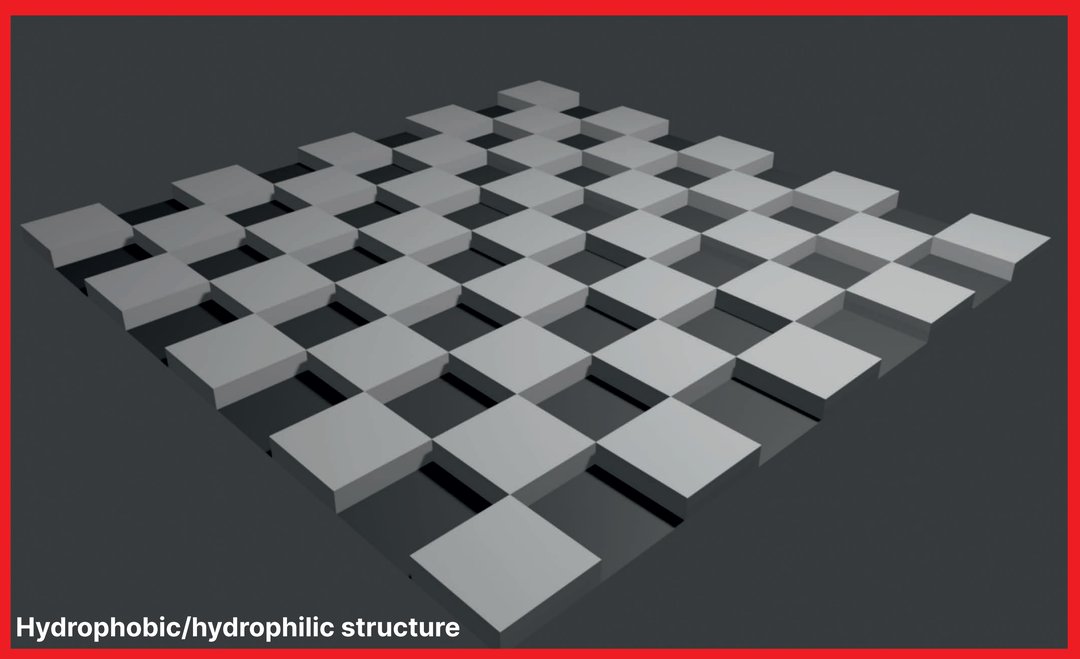
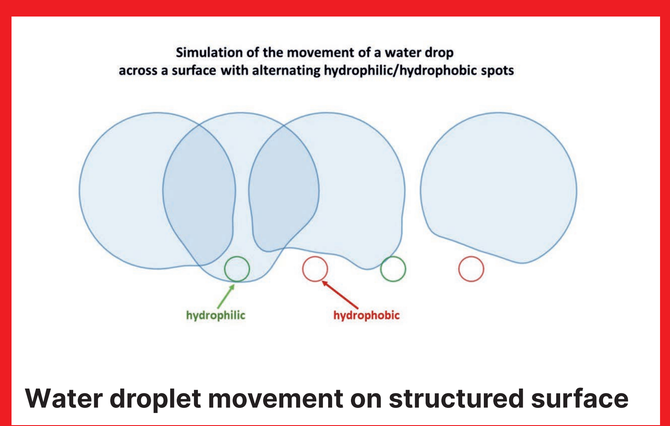
RESEARCH ACTIVITY 3:
DEVELOPMENT, STUDY AND APPLICATION OF MODIFIED NANO-SURFACES

OBJECTIVES

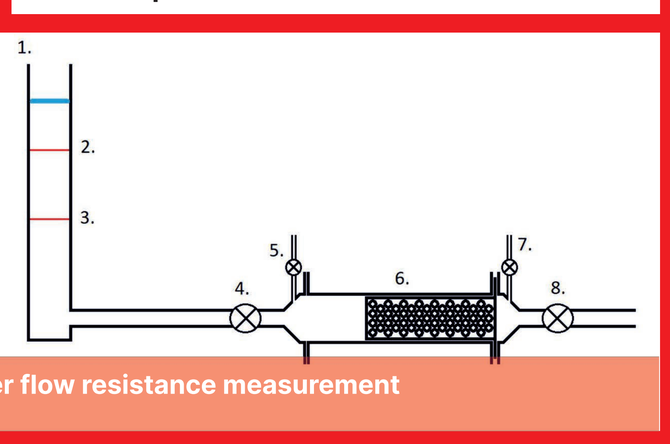
- Development of surface modifications and structures improving functional properties of materials and products.
- Focus on hydrophobic, oil-phobic and antibacterial modifications on structured surfaces (pores materials, textile materials, glass, plastic and metal materials).
- Improvement of hydrodynamic characteristics, tribological and chemical resistance and cleaning properties of surfaces and products.
- Utilization of natural sustainable materials
- Development of measurement techniques for surface properties quantification – effect of friction forces, water flow through porous materials and around objects (glass beads).


Hydrophobic/hydrophilic structure


Test circuit and sample cartridge for water flow resistance measurement



Water droplet movement on structured surface



RESULTS AND OUTPUTS

Application of international patent
K. Voleská - S. Petrík - H. Křížová - Z. Hrubošová: Surface structure of a body, Patent PV 2021-278 / PS4435CZ. The principle of the surface structure consists in that it contains a plurality of highly hydrophobic regions and a plurality of highly hydrophilic regions arranged side by side.

Czech patent, International application in process
Vojtěch Růžek, Petr Louda, Katarzyna Ewa Buczkowska: Antimikrobiální hydrofobizační kapalina pro povrchovou ochranu savých minerálních materiálů PV 2021-587. Invention consists of anti-microbiothical hydrophobic fluid for surface protection of absorbent materials made up of water emulsion with siloxans including metal nanoparticles. These nanoparticles deposited in the pores of the material exhibit anti-microbiothical properties.

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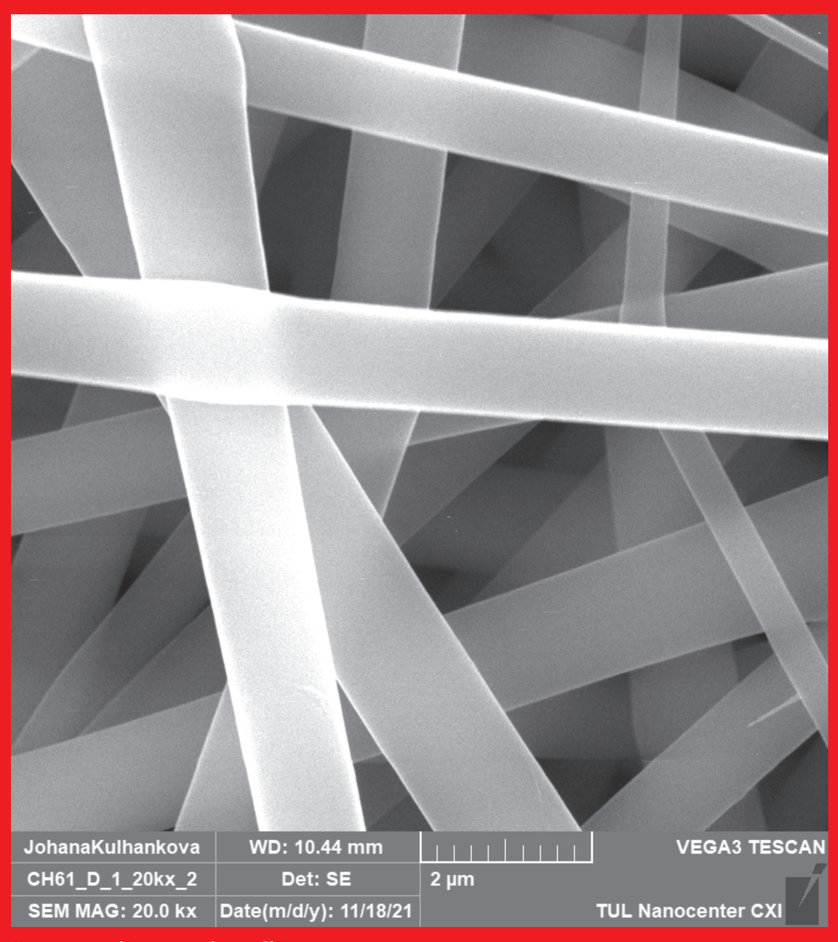
RESEARCH ACTIVITY 4:
PREPARATION OF NANOSTRUCTURES BY ORGANIC SYNTHESIS AND THEIR APPLICATIONS



Organosilane microfibers

OBJECTIVES

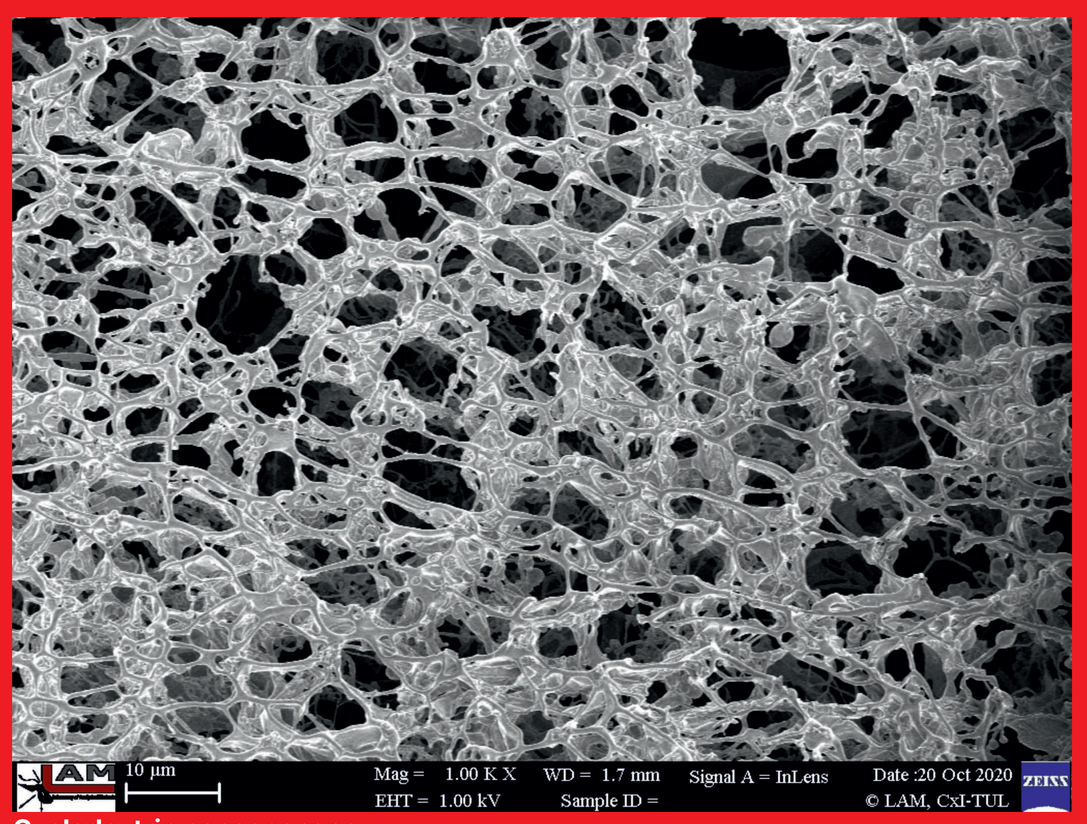
The aim of this work package is to prepare nanostructures (nanofibers, nanosponges, nanoparticles) by organic synthesis and to apply them in drug delivery, tissue engineering, etc. Furthermore, we used technologies that enable solutions to global challenges in areas such as health care and "green" production processes.

Therefore the particular aim is to prepare purely organosilane hybrid fibrous materials and, secondly, to prepare nanosponges based on natural cyclic oligosaccharides – cyclodextrins. The final aim was to test these materials for the abovementioned applications.

RESULTS AND OUTPUTS

During the project, the abovementioned goals were achieved and organosilane precursors were successfully synthesized and fibrous materials were fabricated and tested with promising results. Similarly, the synthesis of cyclodextrin nanosponges was also successful.

Based on the abovementioned results, 12 articles in journals with an impact factor have been published so far, with three quarters of them in journals in the first quartile (according to Web of Science). Furthermore, an international patent application was accepted and several functional samples were created.



Cyclodextrin nanosponges

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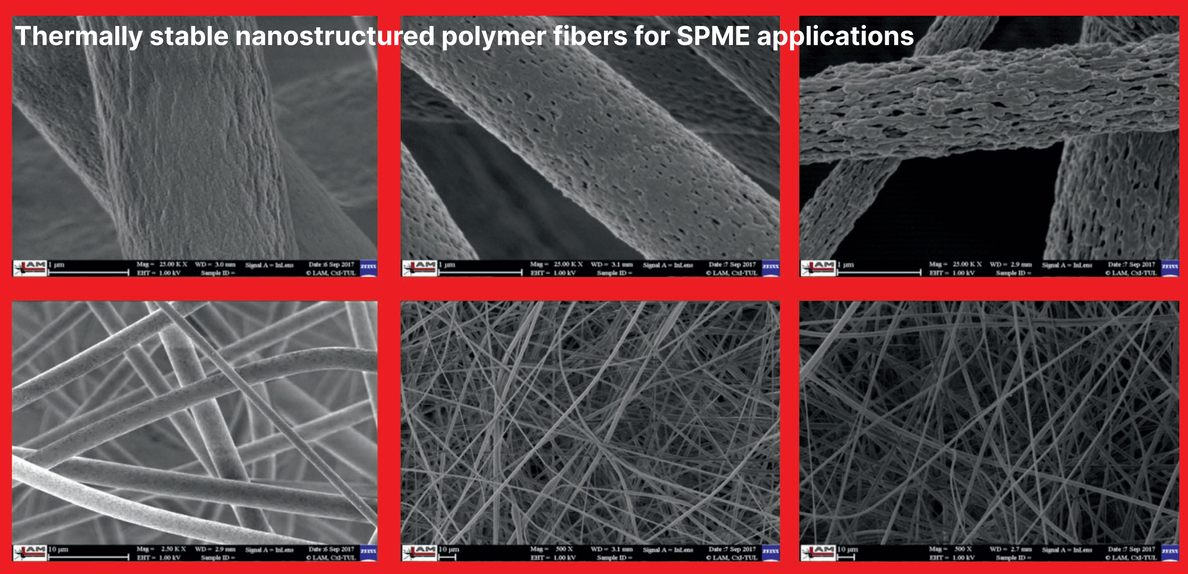
RESEARCH ACTIVITY 5:
NANOSTRUCTURED POLYMERIC SORBENTS FOR BIOTECHNOLOGY AND ENVIRONMENTAL DIAGNOSTICS OF WATER

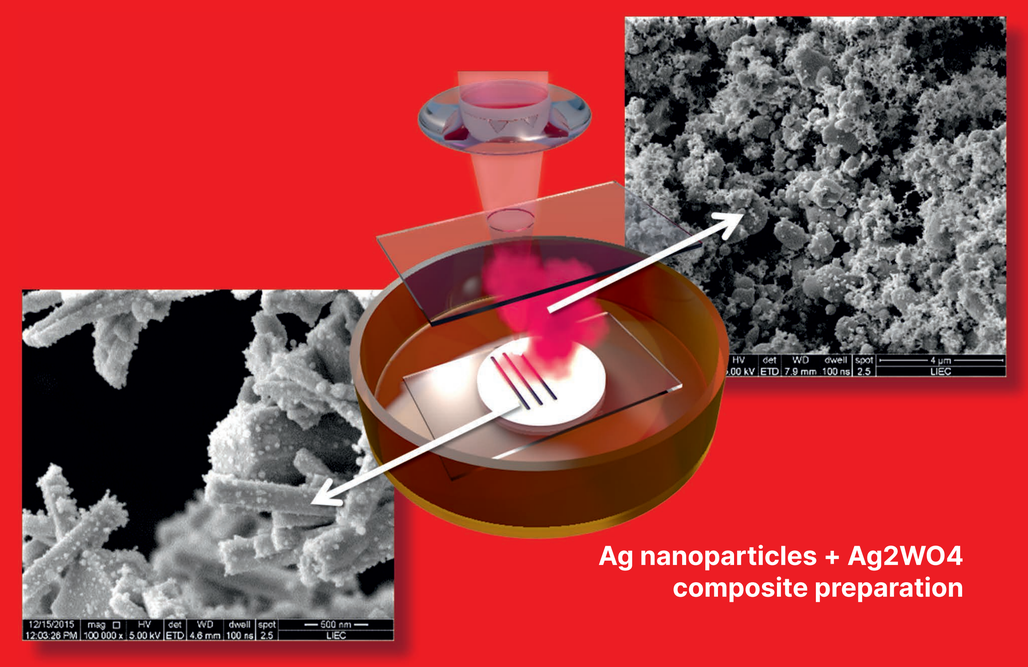
OBJECTIVES

Primarily goals of the activity are to develop sorbents suitable for advanced pre-concentration techniques of organic analytes in instrumental chemical analysis.
For solid-phase microextraction (SPME, coupled with gas chromatography systems), the potential of electrospun nano-structured fibers of thermally stable polymers was planned to explore.
For solid-phase extraction (SPE, coupled with liquid chromatography systems), composites of biopolymers were at focus.
All phases of sorbent research should be performed, from initial screening, surface modification, stability testing, and analytical cycle simulation up to real application in the analysis of environmental pollutants.

RESULTS AND OUTPUTS



- Articles in impacted journals (mostly in highly impacted journals of Q1).
- Articles cover either material topics related to the construction of analytical preconcentration assemblies or to the application of these techniques for environmental diagnostics.
- International patent application (composite of gum kondagogu and MXene preparation).
- Catalog of structures (polyetherimide, polyethersulfone, polysulfone, polyamide – nanofibers-based SPME assemblies).
- Testing methodologies (testing of thermal stability of SPME assemblies in repeated thermal cycles).
- PhD. thesis of MSc. Vojtěch Antoš (Nanofibrous sorbents for analytic extractions).
- International project (Lifepopwat).



Ag nanoparticles + Ag2WO4 composite preparation

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