Erasmus+ Blended Intensive Programme

NANOMATERIALS FOR MEDICAL AND TECHNICAL APPLICATIONS (N4MTA)

Nanomaterials for Medical and Technical Applications (N4MTA) - Timetable				
Webinars	**Date**	**Time (GMT+1)**	**Topic**	**Lecturer**
April	01.04. Wed	4:00 PM	Introduction to BIP N4MTA	Jan Valtera, TUL
	09.04. Thu	4:00 PM	Introduction to the Realm of Nanofibers	David Lukáš, TUL
	16.04. Thu	4:00 PM	Technologies for Production of Nanofibers; Design Concepts of Electrospinning Devices & Spinning	Jan Valtera, TUL
	23.04. Thu	4:00 PM	Simulation of Electric Field of a Spinning Electrode	Jan Valtera, TUL
	30.04. Thu	4:00 PM	Nanoparticles: significance, characteristics & application; Student Project Assignement;	Laszlo Mészáros, BME Jan Valtera, TUL
May	07.05. Thu	4:00 PM	Medical Textiles	Caroline Emonts, RWTH
	14.05. Thu	4:00 PM	Testing, Analysis & Application of Nanofibers in Medicine	Eva Kuželová Košťáková, TUL
	21.05. Thu	4:00 PM	Nanofiber materials for advanced filtration; Summer School Final Programme Presentation; Open floor for discussion	Josh Manasco, Elmarco Jan Valtera, TUL
May - mid June	indiv.	indiv.	Self study & work in international teams	all students / all supervisors
June	22.-26.6.	full day	Summer School	

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1. Introduction to BIP Nanomaterials for Medical & Technical Applications

Nanomaterials are used in various areas, spanning from technical to medical applications. This programme focuses on nanotechnologies for the production of nanofibers for medical applications. The aim of this project is to bring together students and staff from various universities to share state-of-the-art knowledge in the areas of nanotechnologies, nanofibers, their analysis, and applications.

The seminar consists of:

- Goal's and conditions of Erasmus+ Blended Intensive program (BIP)
- Presentation of involved universities and participants
- Presentation of the N4MA course schedule
- Workshop about the MS Teams tool for sharing course materials
- Establishment of student working teams

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2. Introduction to the Realm of Nanofibers

This seminar focuses on the history of the research in nanofiber production, the physical background of the electrospinning process and the potential of nanofiber materials for medical applications.

The seminar consists of:

- Nanofibers and extracellular matter
- History of preparation of nanofibers and related theoretical approaches
- Electrospinning – theory, experiments and technology
- Nanofibers for biological ingestion
- Unresolved issue

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3. Technologies for Production of Nanofibers,
Design Concepts of Electrospinning Devices & Spinning Electrodes

There are many techniques for the production of polymeric nanofibers invented and several of them have been used in laboratory or industrial scale. The upscaling potential of the technology for industrial-scale applications, while maintaining the required conditions for material homogeneity and repeatability, plays a crucial role. Machines and devices for the production of nanofibers using electrospinning technology need to fulfil specific requirements, such as those related to the chemicals used in the polymeric system, high electrical voltage, safety features, and many others. One of the key elements of these devices is the spinning electrode, whose design significantly affects the nanofiber properties and nanofibrous structure.

The seminar consists of:

- Machine layout for production of linear nanofibrous structures and membranes
- Systems of substrate winding for nanofiber deposition / substrate-free nanofibrous structures production
- General design concept of DC and AC electrospinning devices (electric insulation, chemical resistance of materials, safety risks evaluation and elimination)
- Spinning electrodes for DC and AC technology (principles, types, laboratory/industrial scale)
- Polymeric dosage systems used in the electrospinning process
- Drive units of machine elements operating under high voltage (electrodes, pumps, etc.)

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4. Simulation of the Electric Field of the Spinning Electrode

Spinning electrodes are a key element of electrospinning devices. Its design and geometry of the spinning zone affect the nanofiber properties as well as the nanofibrous structure. In order to define the optimal electrode design, analyses of the electrical field in its surroundings need to be calculated.

The seminar consists of:

- General concept of spinning electrodes
- Analytical calculation of the electrical field intensity of an electrode with a simplified shape
- Calculation of the electrical field of an electrode using the finite element method (geometry definition, boundary conditions, mesh settings, results interpretation)
- Introducing the software FEMM 4.2 for calculating steady static electrical field problems for the simulation of the electrical field intensity of the electrode with desired geometry

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5. Nanoparticles: significance, characteristics and application

The lecture explores how nanoscale dimensions fundamentally change material behaviour. Why do nanoparticles have such a strong influence on mechanical performance, stiffness, and structural response? How do they interact with polymers, fibres, and matrices? And what role does the interphase play in these effects?

The seminar consists of:

- The size effect in materials – how nanoscale dimensions modify physical and mechanical properties.
- Production of nanoparticles – key approaches and practical relevance.
- Types and properties of nanoparticles – including silicates and carbon-based nanoparticles.
- Utilisation of nanoparticles – with examples in polymer matrices, fibres and hybrid systems.
- Interphases and their role – how nanoparticles create interaction zones that govern composite behaviour.

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6. Medical Textiles

The field of medical textiles has become increasingly significant in the modern medical context, particularly with regard to the development of innovative solutions for a range of clinical applications. This module offers a systematic introduction to the field of medical textiles, with a focus on specific application areas, including cardiovascular applications. A variety of products will be introduced, and their properties and potential uses will be described in detail. In addition, the presentation will address the essential processing technologies that are required for the fabrication of these specialised textiles.

The seminar consists of:

- Introduction to medical textiles and their significance.
- Overview of selected applications and specific products.
- Detailed description of processing technologies for medical text

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7. Testing, Analysis & Application of Nanofibers in Medicine

Fibres and fibrous materials are exceptional in terms of their properties and the flexibility and variability of technological processes, leading to a huge number of variations in the resulting products. The realisation that fibre is a unique building block of materials leads to an understanding of the unique and inimitable properties of fibrous and nanofibrous materials. The creation of nanofibrous polymeric materials by electrospinning technology offers their use for medical applications such as wound covers, cell carriers (scaffolds) for tissue engineering or drug delivery systems. Various hierarchically modified nanofibrous materials for medical applications will be presented. With their structure, nanofiber materials resemble the natural extracellular matrix (ECM) and therefore have a great potential for use in tissue engineering. Nanofibrous materials have suitable properties for ECM replacement, especially a great surface-to-volume ratio, enabling the adsorption of proteins and subsequent cell adhesion and proliferation. With regard to the target tissue, these materials can be prepared from different polymers and with specific structures. Thin nanofibre layers are suitable as wound covers, fluffy 3D structures are candidates for bone and cartilage tissue engineering, and oriented fibres can be used to treat spinal injuries or muscle injuries. Successful materials should have suitable physicochemical properties (porosity, fibre diameter, 3D structure, mechanical properties, wettability, etc.), be biocompatible, and exhibit appropriate degradation behaviour. The results of clinical testing of an electrospun nanofibrous biodegradable wound will also be presented.

The seminar consists of:

- Nanofibrous materials for tissue engineering (examples of production and final materials)
- Physico-chemical testing of nanofibrous materials for tissue engineering (with a focus on scanning electron microscopy)
- Biological testing of nanofibrous materials (cytotoxicity, biocompatibility, degradation behaviour

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