Erasmus+ Blended Intensive Programme

NANOMATERIALS FOR MEDICAL APPLICATION (N4MA)

1. Introduction to BIP Nanomaterials for Medical Application

Nanomaterials are used nowadays in many areas from technical to medical related fields. This programme focuses on nanotechnologies for production of nanofibers for medical application. The aim of this project is to bring together students and staff from various universities and share the state-of-art knowledge in the area of nanotechnologies, nanofibers, their analyses and application.

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 E-learning module for sharing course materials
- Establishment of student working teams

JAN VALTERA | +420 737 820 865 | jan.valtera@tul.cz
Technical university of Liberec | Faculty of Mechanical Engineering | Department of Textile Machine Design
Studentská 1402/2, 461 17 Liberec 1, Czech Republic | www

2. Introduction to the Realm of Nanofibers

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

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

DAVID LUKÁŠ | +420 485 353 146 | david.lukas@tul.cz
Technical university of Liberec | Faculty of Science, Humanities and Education | Department of Chemistry
BioING team | Studentská 1402/2, 461 17 Liberec 1, Czech Republic | www

3. Technologies for production of Nanofibers and Nanofiber Structures

There are many techniques for production of polymeric nanofibers invented and several of them have been used in laboratory or industrial scale. The upscaling potential of the technology for the industrial scale while maintain the required conditions for material homogeneity and repeatability plays important role.

The seminar consists of:

- Technologies for production of polymeric nanofibers (electrospinning, drawing, force spinning, melt blown, etc.)
- Machine layout for production of linear nanofibrous structures and membranes
- Systems of substrate winding for nanofiber deposition / substrate free nanofibrous structures production

JAROSLAV BERAN | +420 485 353 171 | jaroslav.beran@tul.cz
Technical university of Liberec | Faculty of Mechanical Engineering | Department of Textile Machine Design
Studentská 1402/2, 461 17 Liberec 1, Czech Republic | www

4. Design Concepts of Electrospinning Devices and Spinning Electrodes

Machines and devices for production of nanofibers using the electrospinning technology need to fullfill specific requirements related for example to chemicals of used polymeric system, high electrical voltage, safety features and many others. One of the key elements of these devices are the spinning electrodes whose design affects the nanofiber properties and nanofibrous structure considerably.

The seminar consists of:

- 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.)

JAN VALTERA | +420 737 820 865 | jan.valtera@tul.cz
Technical university of Liberec | Faculty of Mechanical Engineering | Department of Textile Machine Design
Studentská 1402/2, 461 17 Liberec 1, Czech Republic | www

5. Simulation of Electric Field of the Spinning Electrode

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

The seminar will consists of:

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

JAN VALTERA | +420 737 820 865 | jan.valtera@tul.cz
Technical university of Liberec | Faculty of Mechanical Engineering | Department of Textile Machine Design
Studentská 1402/2, 461 17 Liberec 1, Czech Republic | www

6. 3D Braiding for Ligament Tissue Engineering

The anterior cruciate ligament (ACL) is the most commonly injured intra-articular ligament of the knee. Due to its limited intrinsical healing potential and vascularization, injuries of the ACL do not heal satisfactorily, and surgical intervention is usually required. The limitations of existing reconstructive grafts and autologous transplants have prompted interest in tissue-engineered solutions. A tissue engineering scaffold for ACL reconstruction must be able to mimic the mechanical properties of the native ligament, provide sufficient porosity to promote cell growth of the neoligament tissue, and be biodegradable. The presented study investigates long-term biodegradable poly-ε-caprolactone (PCL)-based scaffolds for ACL replacement using the 3D hexagonal braiding technique.

The seminar will consists of:

- Introduction in ligament tissue engineering
- General concept of braiding technologies and 3D-braiding
- Introduction into different braiding geometries for hexagonal 3D-braidin

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 realization that fiber 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 great surface to volume ratio enabling 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, oriented fibers can be used to treat spinal injuries or muscle injuries. Successful material should have suitable physico-chemical properties (porosity, fiber diameter, 3D structure, mechanical properties, wettability, etc.), must be biocompatible and should have appropriate degradation behaviour. The results of clinical testing of an electrospun nanofibrous biodegradable wound will also be presented.

The seminar will consist of:

Nanofibrous materials for tissue engineering (examples of production and final materials)

Physico-chemical testing of nanofibrous materials for tissue engineering (with focuse to scanning electron microscopy)

Biological testing of nanofibrous materials (cytotoxicity, biocompatibility, degradation behaviour)

EVA KUŽELOVÁ KOŠŤÁKOVÁ & VĚRA JENČOVÁ | +420 485 354 004 | eva.kostakova@tul.cz
Technical university of Liberec | Faculty of Science, Humanities and Education | Department of Chemistry
BioING team | Studentská 1402/2, 461 17 Liberec 1, Czech Republic | www

8. Nanoparticles: significance, characteristics and application

So far, the course has focused on nanofiber production technologies. But why are these nanofibres useful? In particular, why do we use nanoparticles? What are their advantages and disadvantages? And what are the origins of these properties?

The seminar will consists of:

- The size effect in case of the materials.
- Production of nanoparticles.
- Types and properties of nanoparticles.
- Utilization of nanoparticles.
- Preparation and structure of nanocomposites.

LÁSZLÓ MÉSZÁROS | +36-1-463-1056 | meszaros@pt.bme.hu
Budapest University of Technology and Economics | Faculty of Mechanical Engineering
Department of Polymer Engineering | Studentská 1402/2, 461 17 Liberec 1, Czech Republic | www