New Opportunities for the Development of Education at the Technical University of Liberec

Specific objective A2: Development in the field of distance learning, online learning and blended learning

NPO_TUL_MSMT-16598/2022

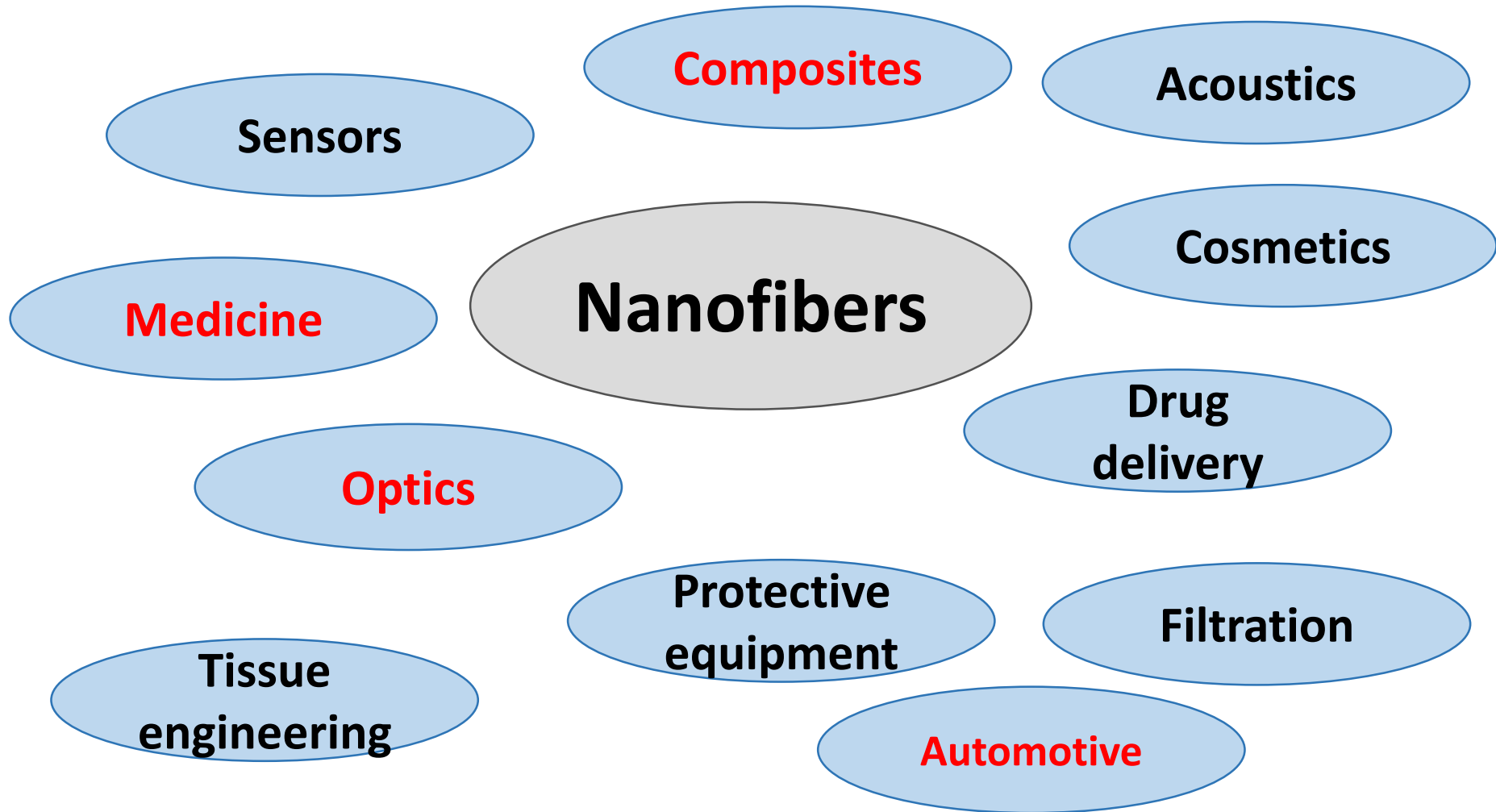# KNT_TNA_Application of nanofibers

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# Fields of activity

Filtration

- Removal of substances from the medium (**air** or **liquid**)
- **Particulate filtration from air:**
- The ideal air filter should effectively trap particles while allowing air to flow

- Examples of use:
  - Household
  - Filters in cars
  - Army (uniforms, decontamination)
  - Healthcare (respirators, drapes)
  - Detection of bacteria and viruses

- Used materials:
  - PA, PI, PVDF, PS, PVA, PP, PAN, etc.



(a)

Scaffold nanofiber
Thin nanofiber
Microsphere
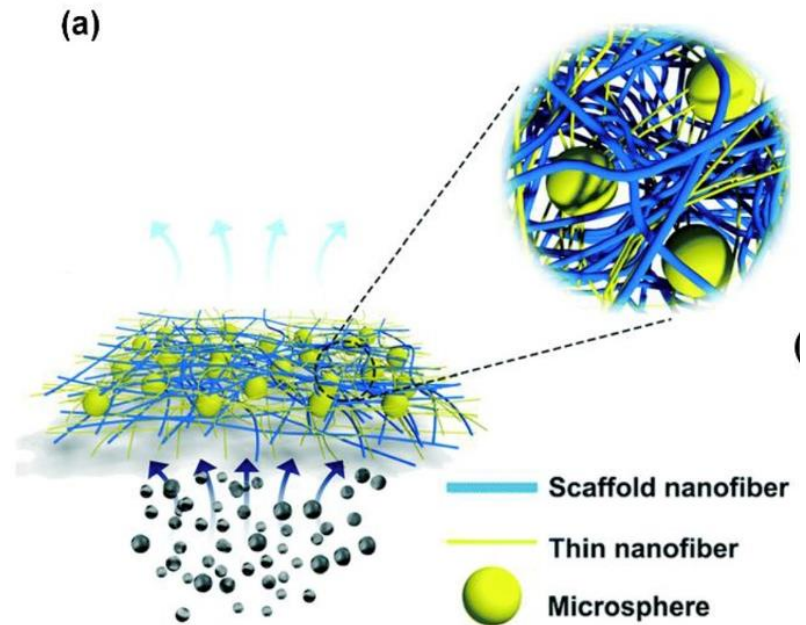
Filtration

- Removal of substances from the medium (**air** or **liquid**)
- **Filtration of particles from a liquid:**
- Capture of solid particles from water or oils. Filters usually require higher temperature resistance or higher demands on mechanical strength (ideal are nanofiber yarns produced by the AC spinning method and formed into the shape of a filter).

- Examples of use:
  - Automotive industry (oil, fuel filters)
  - Wastewater treatment

- Used materials:
 - PA, PS, PAN, etc.

Filtration

- The passage of particles through the filter is blocked both on the surface and in the inner space between the fibers. Smaller particles penetrate the pores, where they are trapped in the fiber network, by impact or electrostatic attraction

- Filtration efficiency is also affected by the physical structure of the filter (fiber diameter, structure, filter thickness, pore size, etc.)

- The ability to capture particles is related to their size.
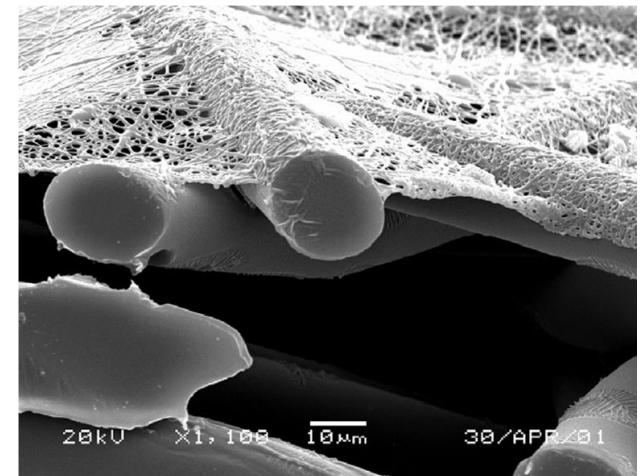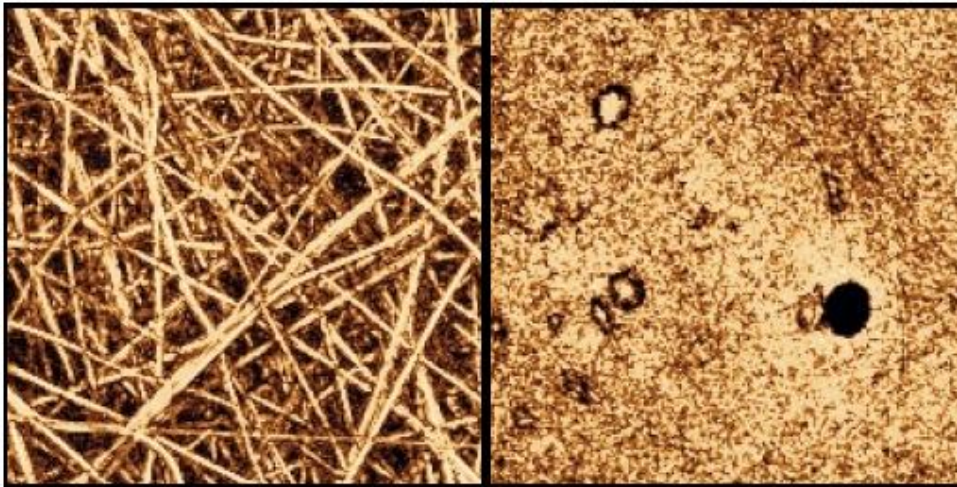
Protective equipment

- Production of filter elements and drapes:
- Electrospinning vs. meltblown
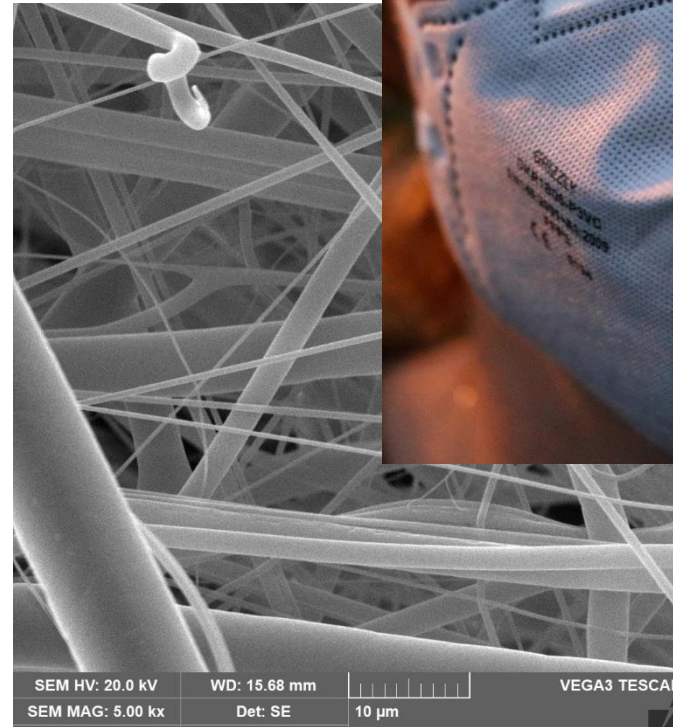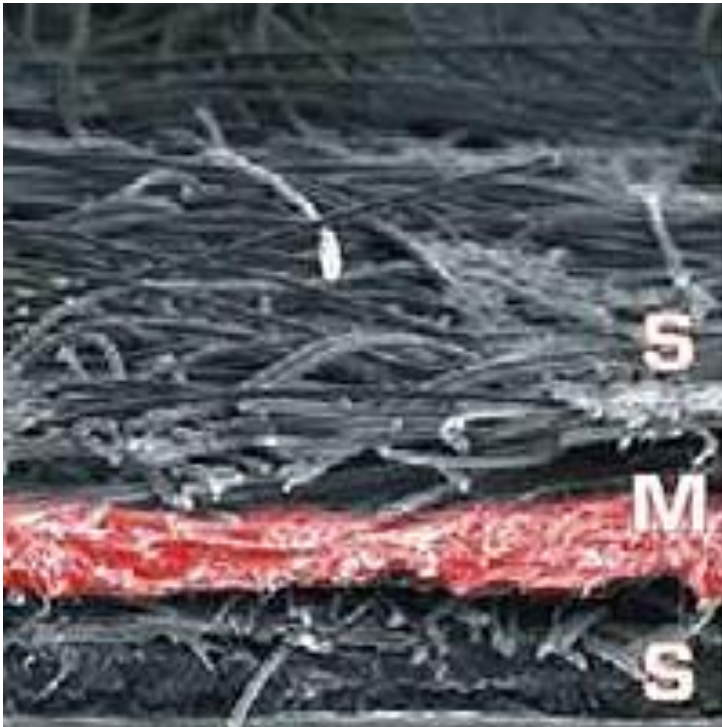

SMS: Spunbond/meltblown/spunbond

Sensors

- Nanofiber sensors are widely used for the detection of chemicals, environmental protection, industrial process control, medical diagnostics, security, smart textiles, etc.

- The sensor should be small in size, high in sensitivity, selective and reliable.

- The material for the sensors must usually be conductive. It is therefore necessary to use either conductive polymers (PANI, PVDF, PVP, etc.). Alternatively, the conductivity of the material can be increased by adding conductive particles (Cu, Ag, ZnO, etc.) or the material can be subsequently coated with a conductive material (coating PPy, PANI, PDA).

Sensors

Conductive Fiber Ionic Fiber Cation Anion
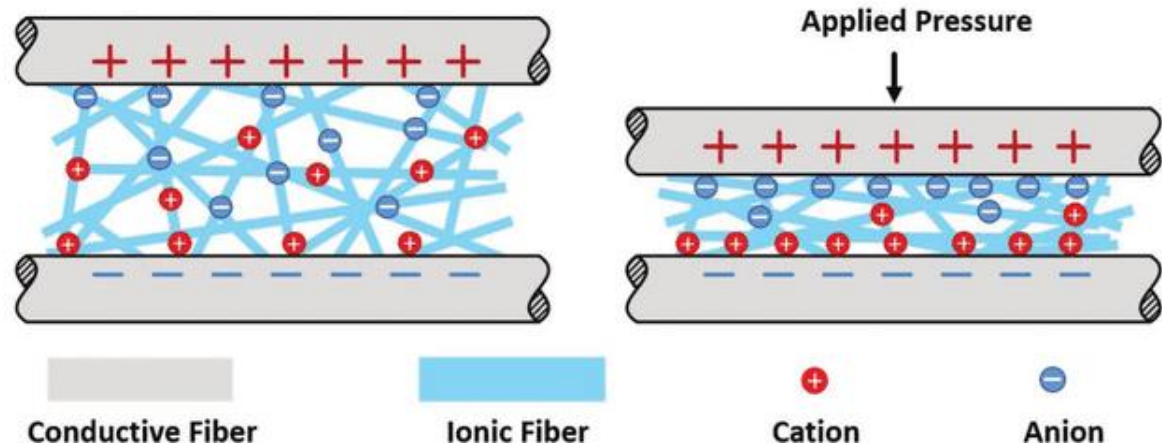
- Pressure sensors
  - Nanofiber pressure sensors are advantageous mainly due to their high bulk density. Under pressure, the fibrous mass is able to indicate changes that can be recorded.

- Gas sensors
  - Some gases can be detected due to the large specific surface area of the nanofibers. The change in conductivity or weight of the fibers is measured

- Photodetectors
  - Some materials can change their color due to the effect of light of different wavelengths, or detect radiation of a specific wavelength (eg UV).

Sensors


Sound absorption performance
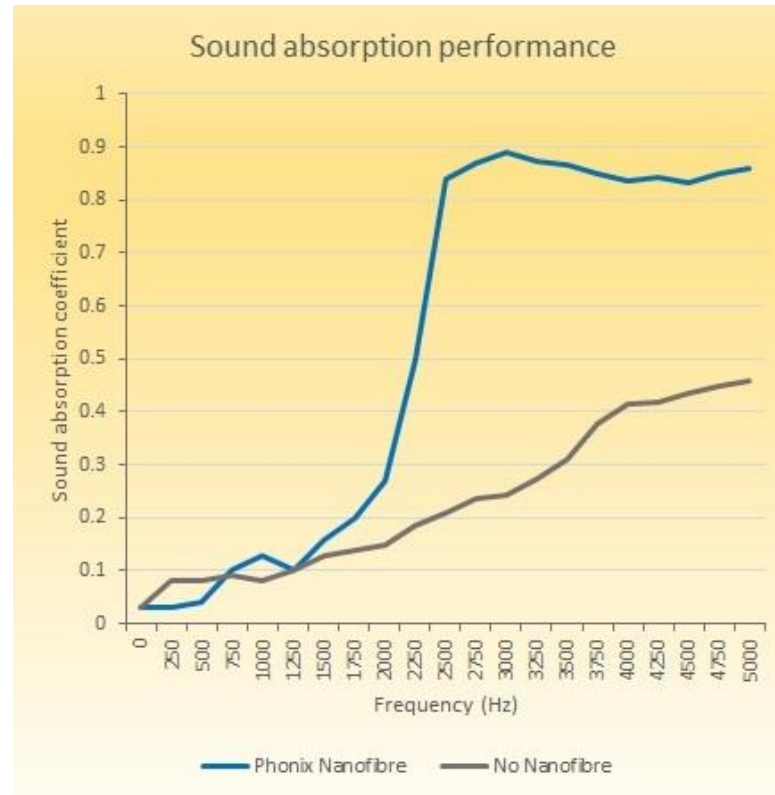
Cosmetics

- Nanofiber face masks
  - Materials made of water-soluble polymers (PVA, hyaluronic acid, water-soluble collagen, etc.) are currently used as face masks containing active substances which are released into the skin upon contact with damp skin.
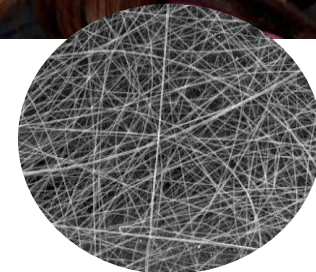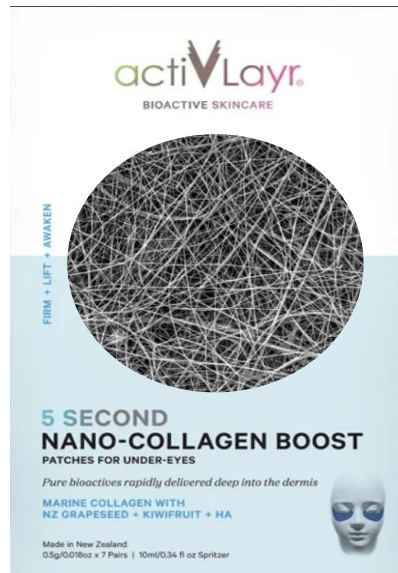
Clothing

- Nanofiber membrane as a variant to the well-known "Goretex®" membrane
 - It produces eg Nanomembrane, material: PA
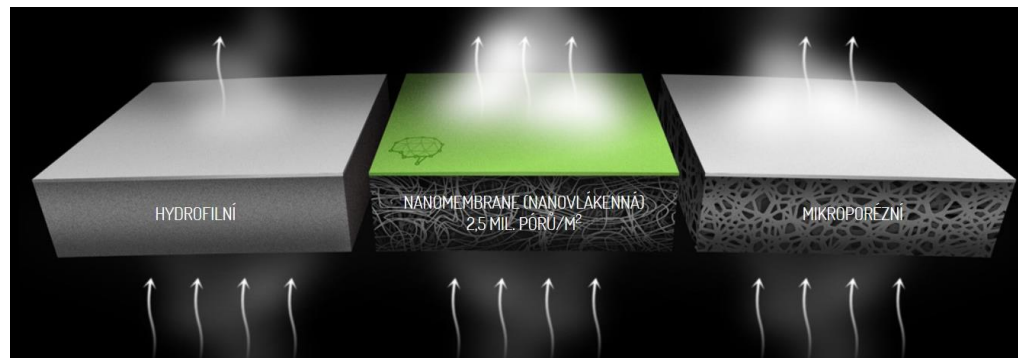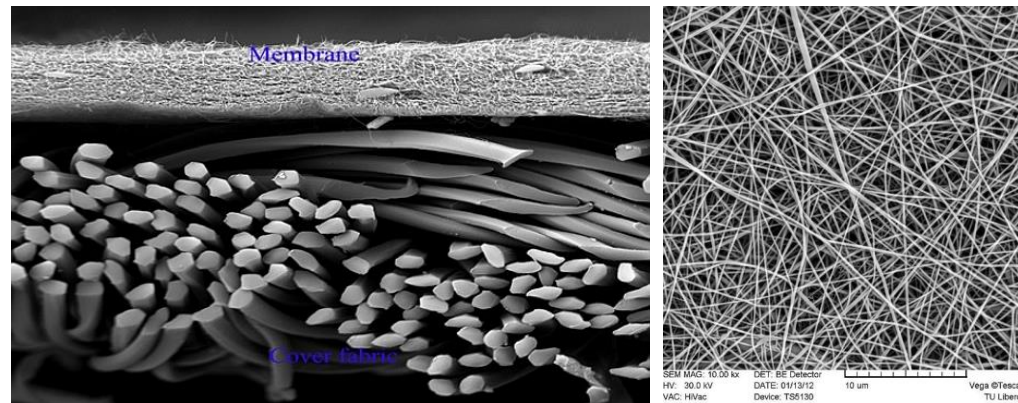
Drug delivery

- Targeted drug delivery systems and their controlled drug release.

- From degradable materials - during the degradation it is possible to control the release of active substances.

- Encapsulation of substances in polymer capsules, coaxial nanofibers, blending
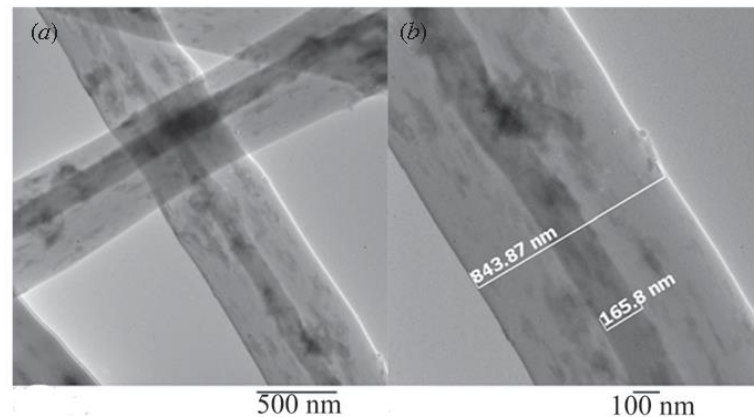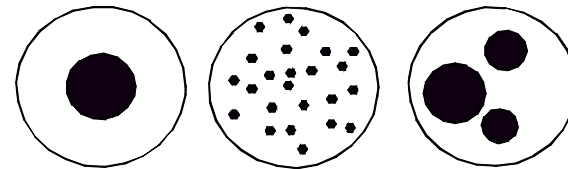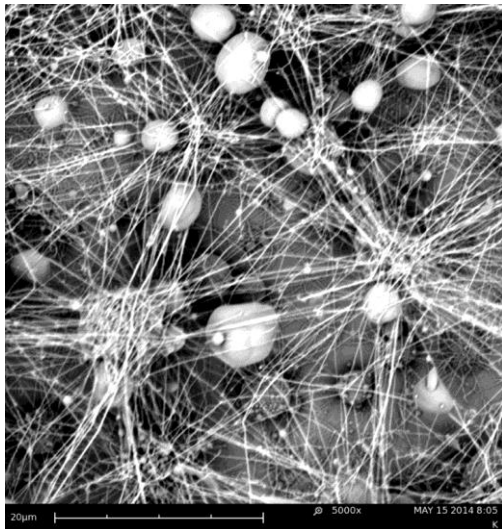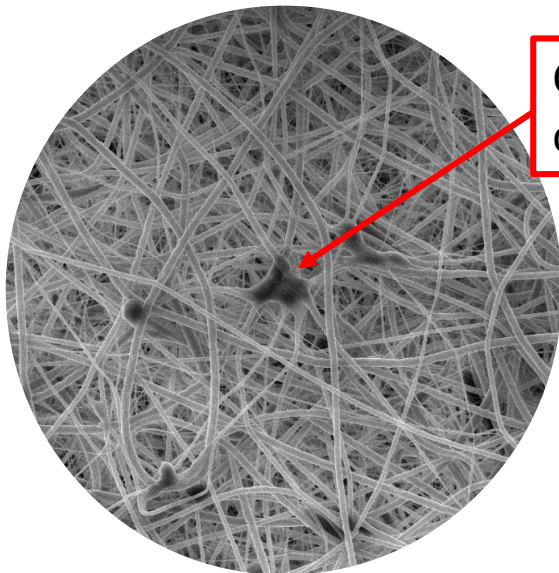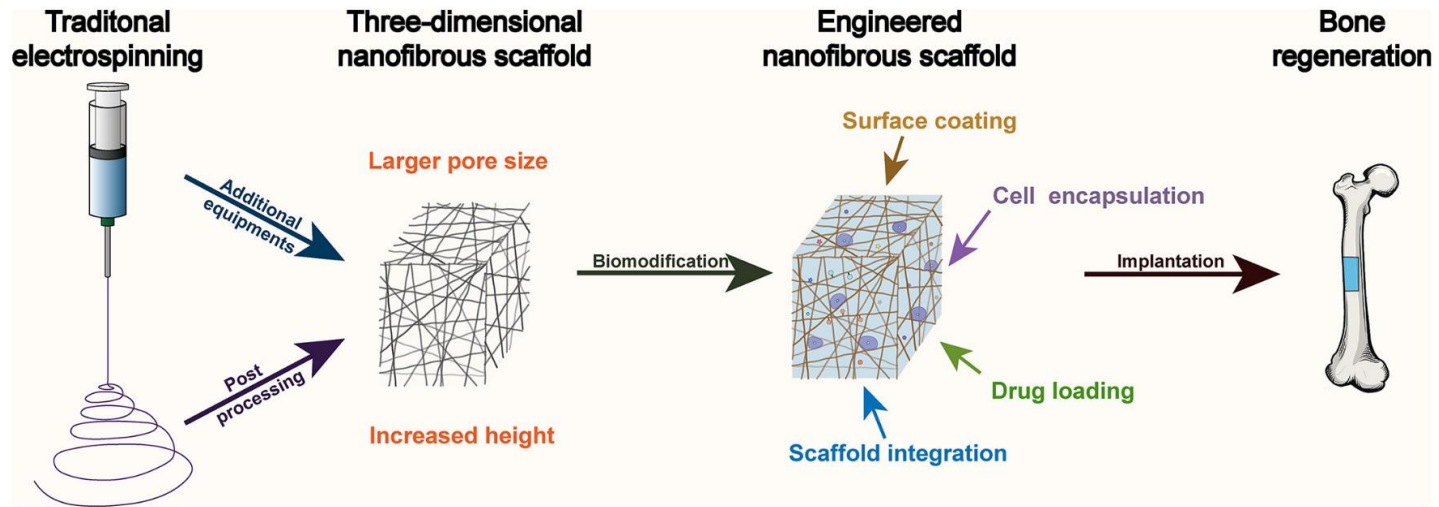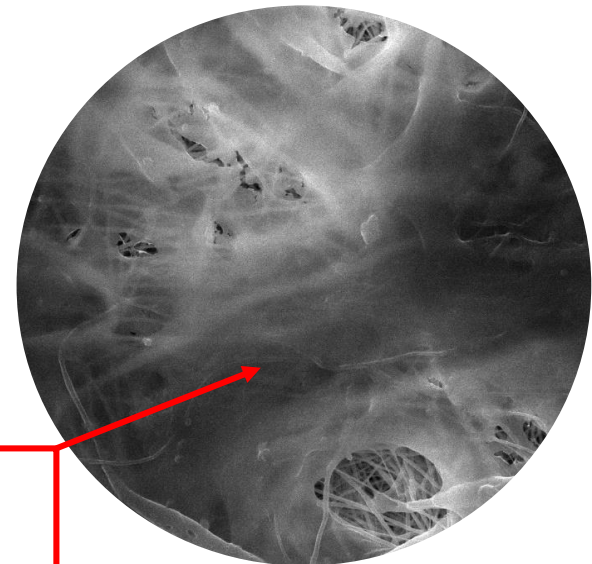
Tissue engineering

- 1) isolation of cells and their proliferation
- 2) production of scaffolds from biocompatible polymers
- 3) fitting the scaffold with cells
- 4) in-vivo implantation
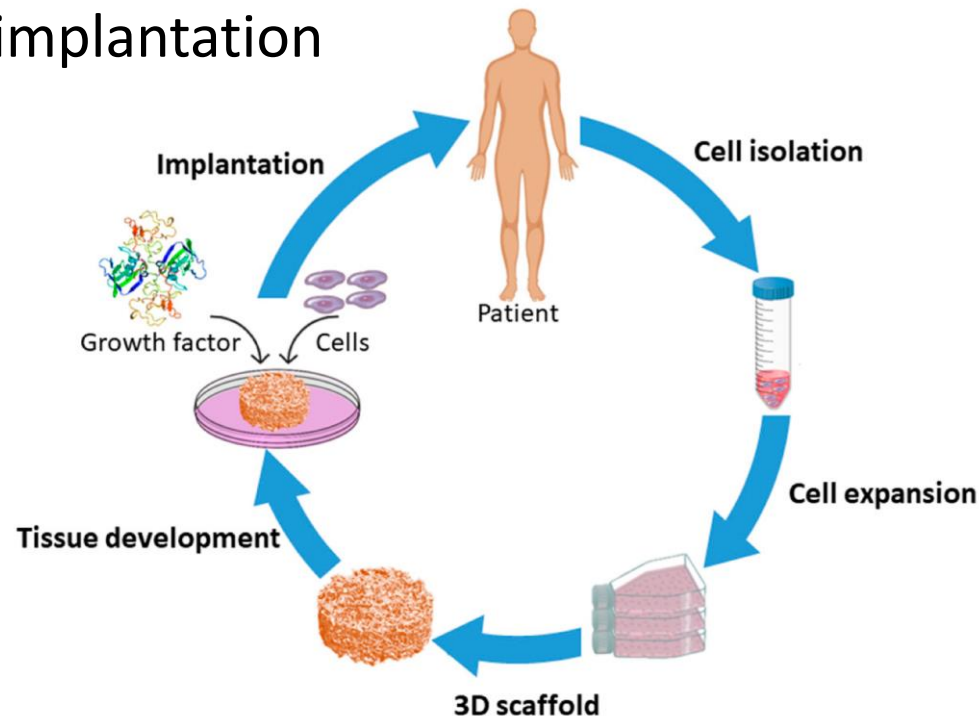
# Tissue engineering

Cell after 3 days of cultivation

Confluent layer of cells after 14 days of culture

Materials for tissue engineering

- Natural materials
  - Collagen
  - Gelatin
  - Cellulose
  - Hyaluronic acid

- Synthetic materials
  - Polyesters (PGA, PLA, PCL, PDX, PHB)
  - Polyvinyl alcohol (PVA)
  - Polyamide (PA)
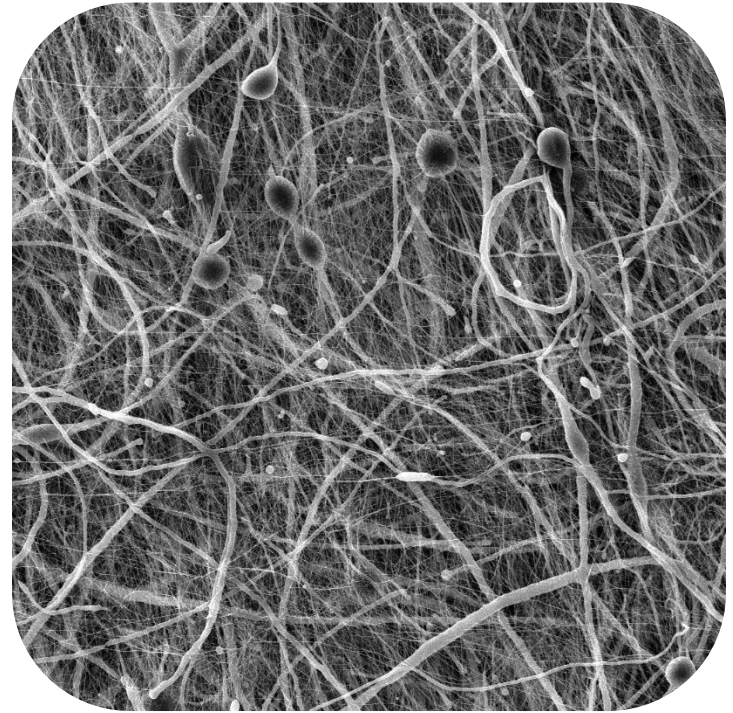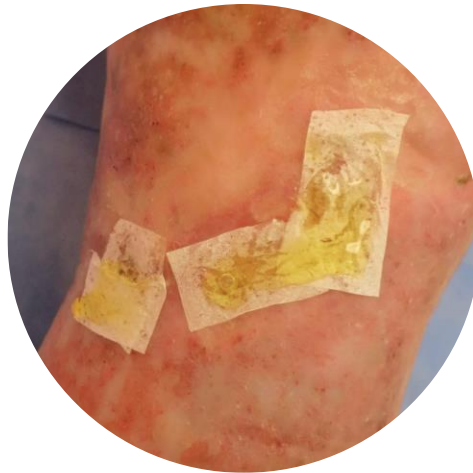 - Polyurethane (PUR)
  - Polyvinylidene fluoride (PVDF)

Vascular replacements

- Biodegradable vascular prosthesis developed at KNT (material: polyesters)
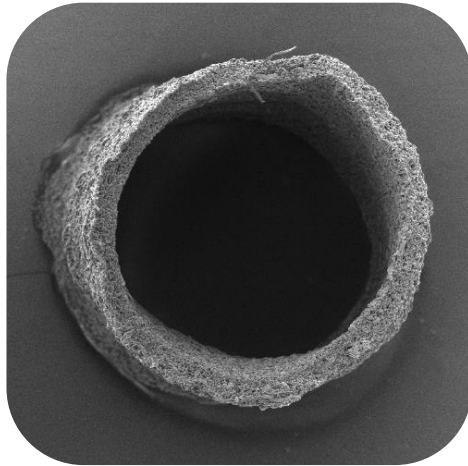
Skin covers

- Nanofiber layer of PCL, which can be used to heal skin defects, burns, etc.

Glaucoma implants

- An implant made of non-degradable PVDF material for the treatment of "glaucoma" must last in the body for the rest of its life. The basis is resistance to cell growth and mimicking the natural tissue in the eye.
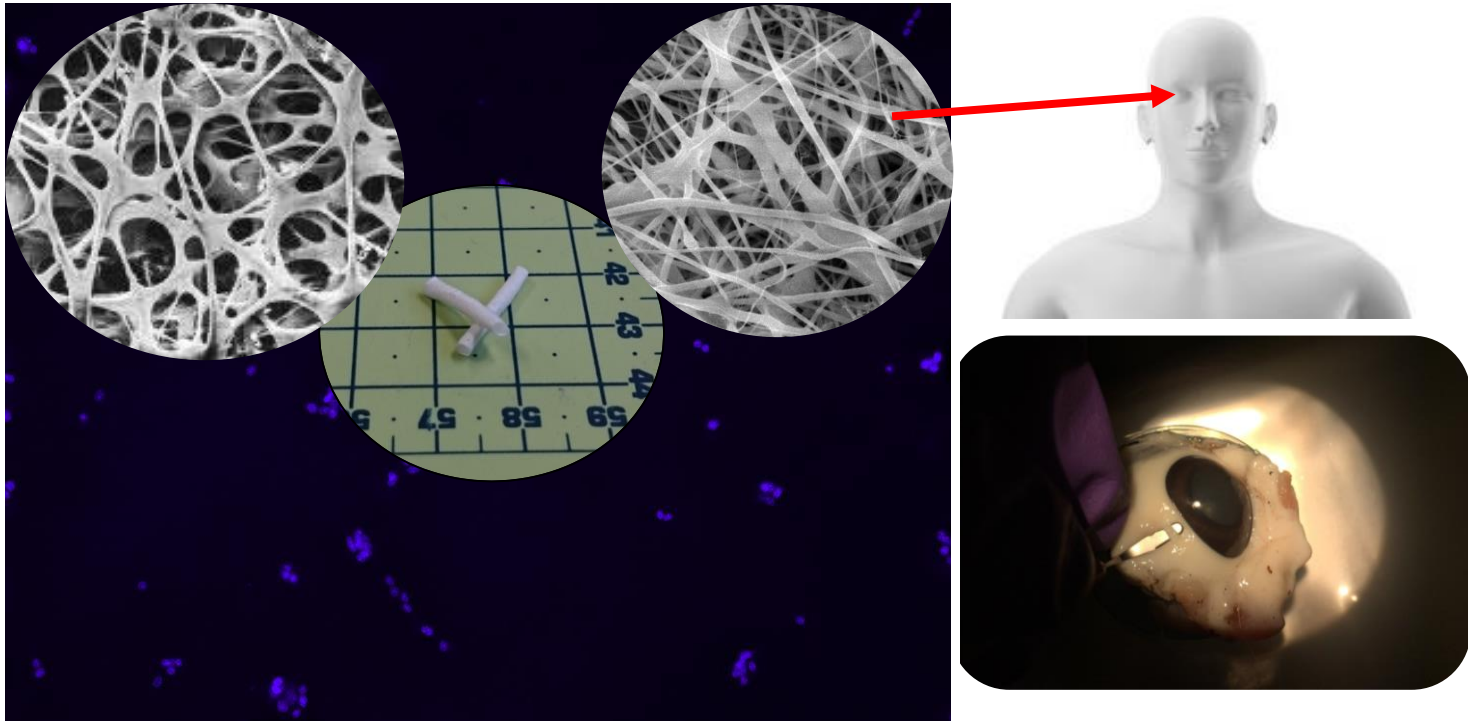
Thymus

- The thymus is an organ that is temporary in our body. It produces so-called T-lymphocytes, which kill tumor cells. We can replace it with the production of 3D scaffolds (a combination of meltblown and electrospinning technologies).
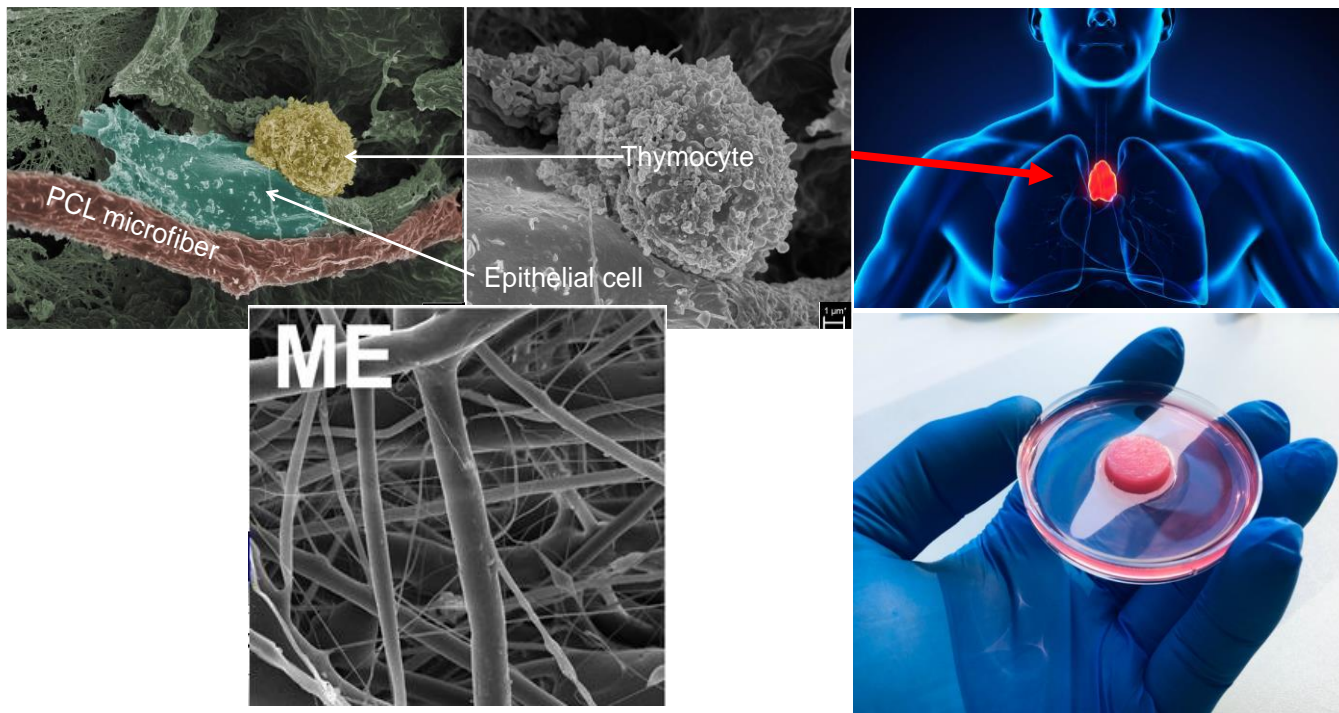
Intestinal anastomoses

- Coverage of intestinal anastomoses, which are a common cause of mortality due to the penetration of intestinal contents into the abdominal cavity. The material prevents the formation of adhesions in the abdominal cavity, a combination of hydrophilic and hydrophobic scaffolds.
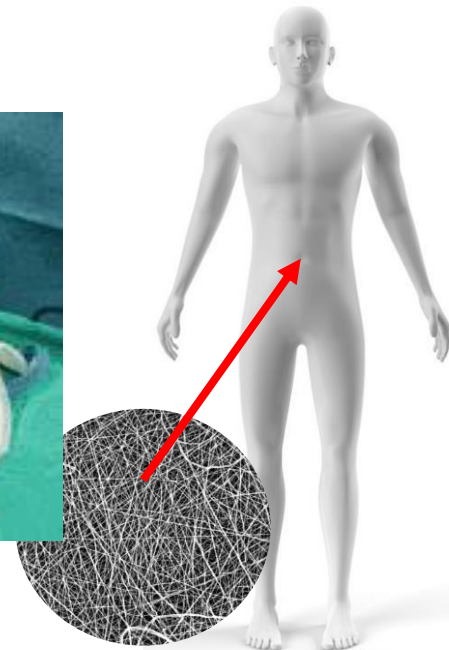
Bone replacements

- Nano / micro fiber scaffolds for bone or joint tissue regeneration can be enriched with hydroxyapatite, their main component. This promotes the growth of bone-forming cells.
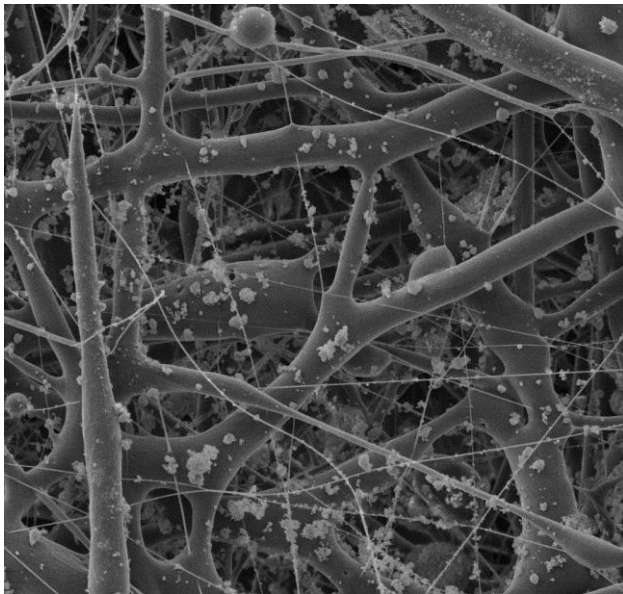
Nerve tissue regeneration

- It is possible to use a special collector in DC electrostatic spinning or drawing technology for the production of parallelized fibers. The application is used, for example, for the regeneration of nerve tissues
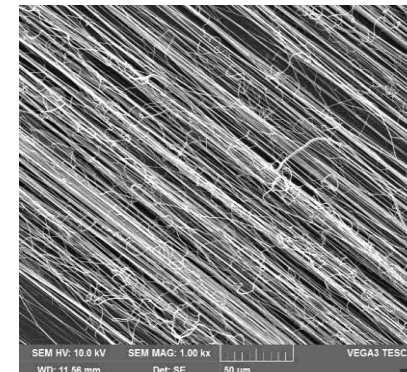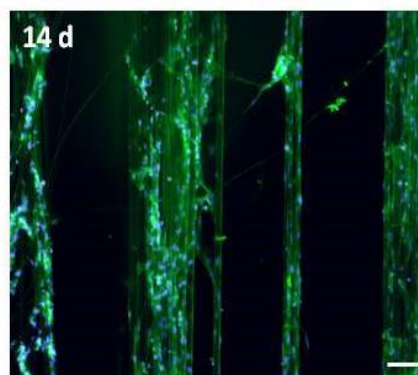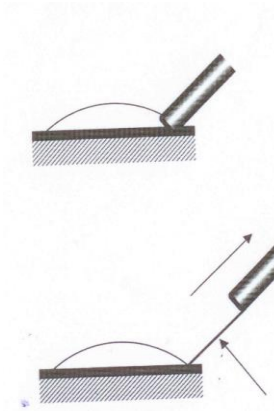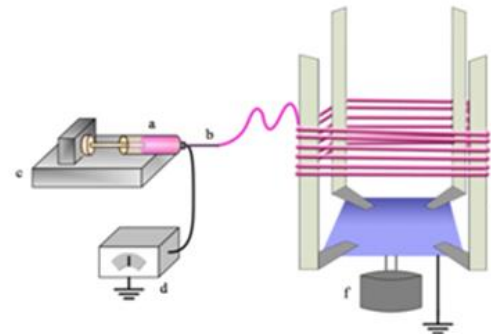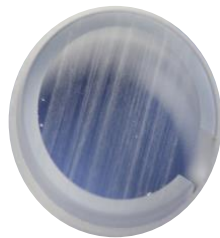
Thank you for your attention!

TEST

- What are the main areas of application of nanofibers?

- What materials are suitable for sensor applications?

- In what applications will coaxial nanofibers find application?

- What is a nanofiber scaffold?

- Describe the most important applications of nanofibers in tissue engineering.