TECHNICAL UNIVERSITY OF LIBEREC

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

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KNT_TNA_Introduction

Ing. Radek Jirkovec, Ph.D.

Funded by the European Union
NextGenerationEU

CZECH RECOVERY PLAN

MINISTRY OF EDUCATION, YOUTH AND SPORTS

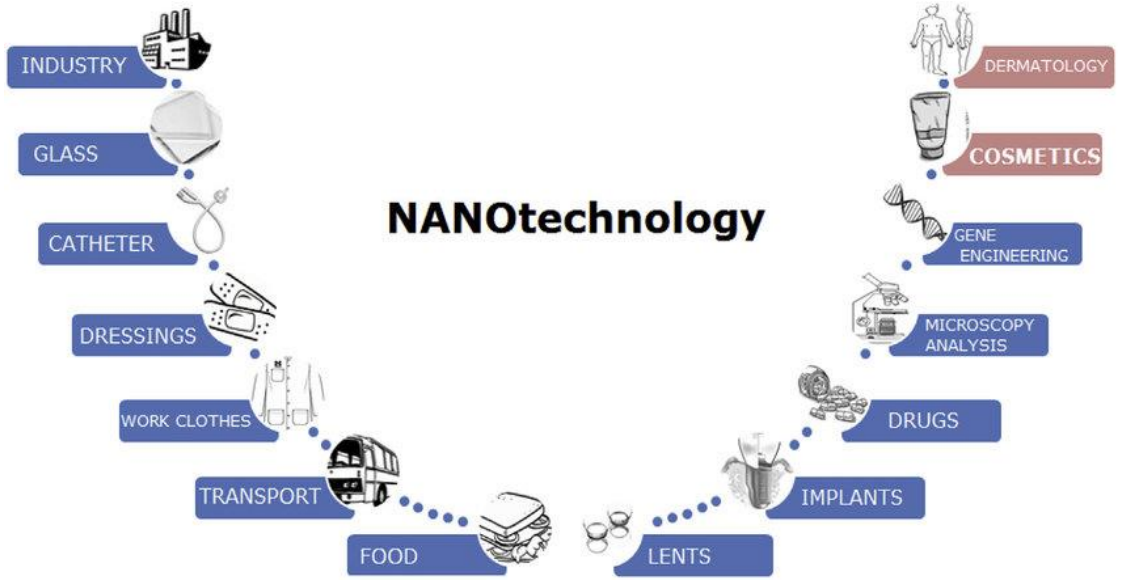
- ***Title:*** Textile nanomaterials

- ***Guarantor:*** doc. Ing. Pavel Pokorný, Ph.D.
- ***Lecturer:*** Ing. Radek Jirkovec, Ph.D.
- ***Tutorial lecturer:*** Ing. Radek Jirkovec, Ph.D., Ing. Tomáš Kalous, Ph.D., Ing. Pavel Holec, Ing. Kateřina Blatoňová, Ing. Jan Vinter

- ***Graded credit:*** 100% completed tutorial, semester work
- ***Exam:*** oral exam

Nanotechnology - a multidisciplinary area of research based on physics, materials engineering, chemistry and biology

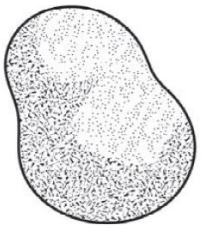
Nanotechnology - a technology that relates to the study, manipulation, development and application of substances, particles and structures on a nanometer scale



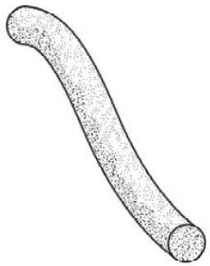
Nanomaterial - a material with one, two or three external dimensions at the nanoscale

Nanoscale - length range from approximately 1 to 100 nm(1nm = $1m^{-9}$)

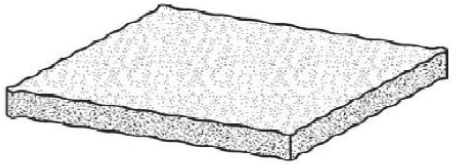
ISO/TS 80004-2:2015 Nanotechnologies—Vocabulary—Part 2: Nano-objects



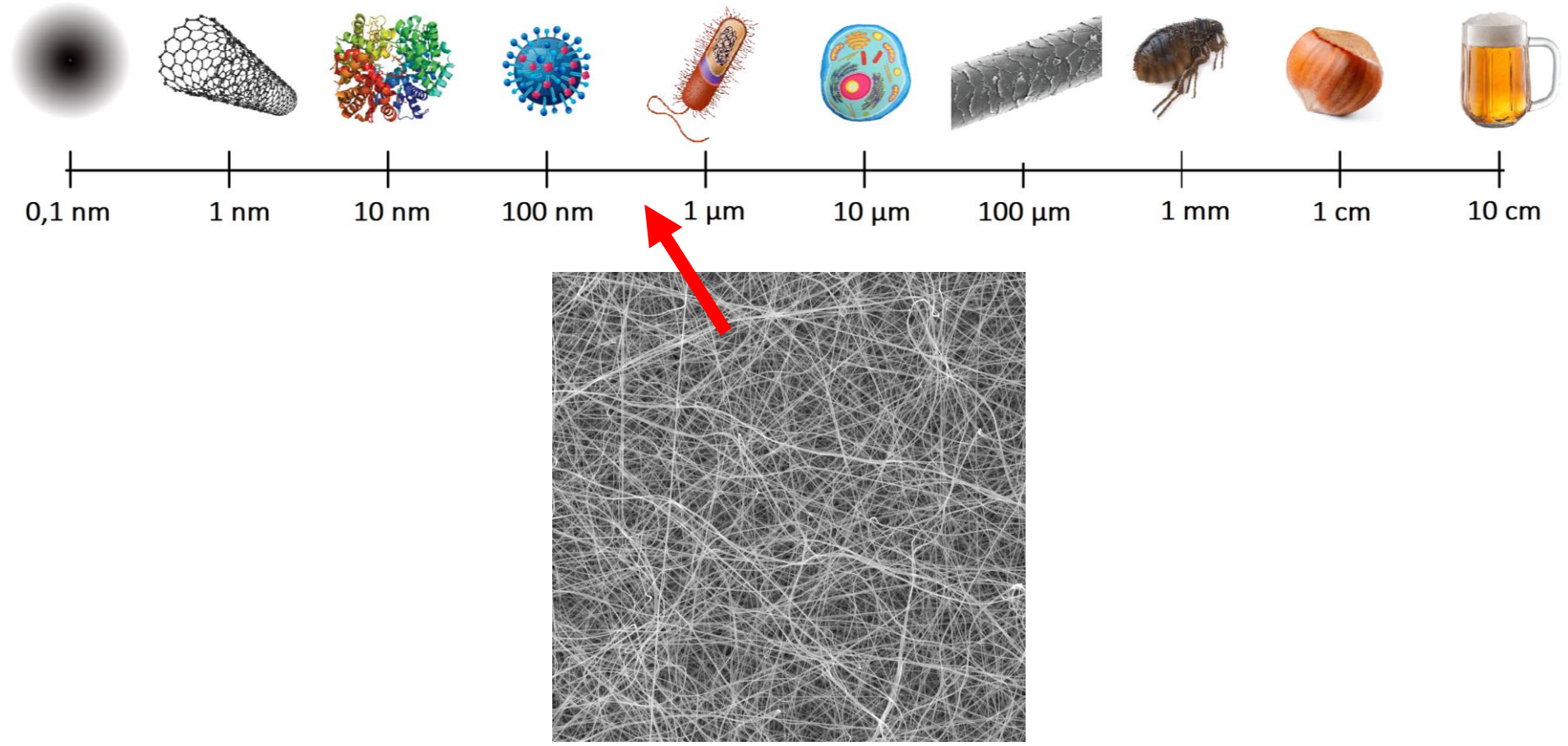
Nanoparticles
Three dimensions at the nanoscale

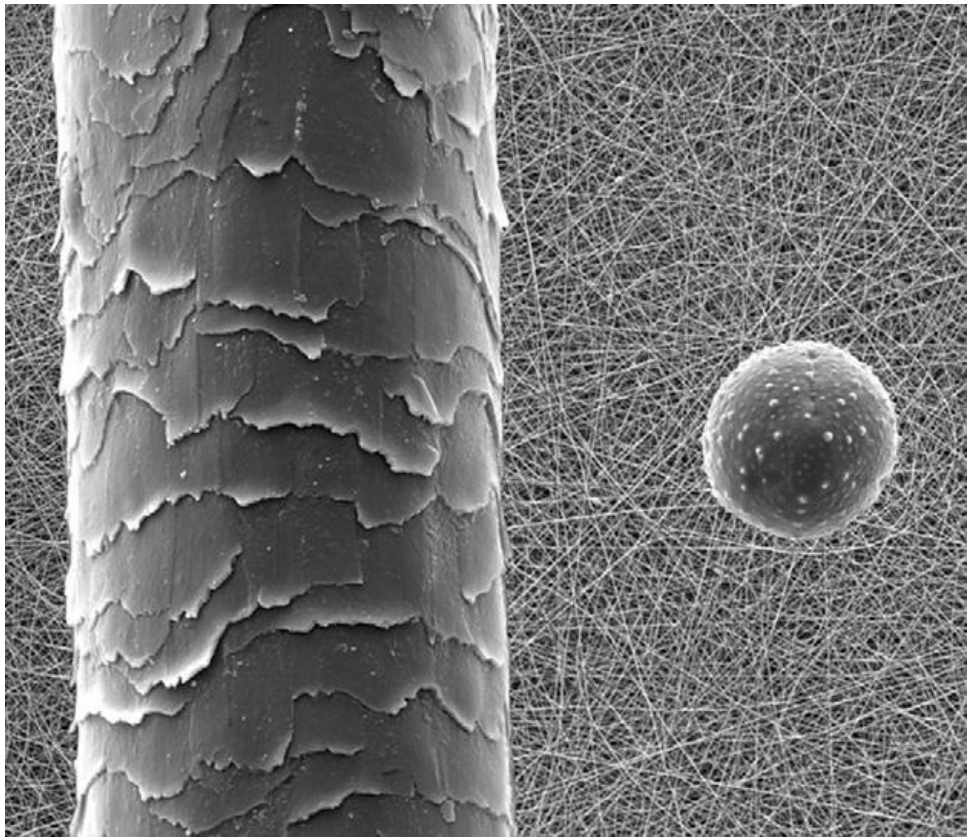


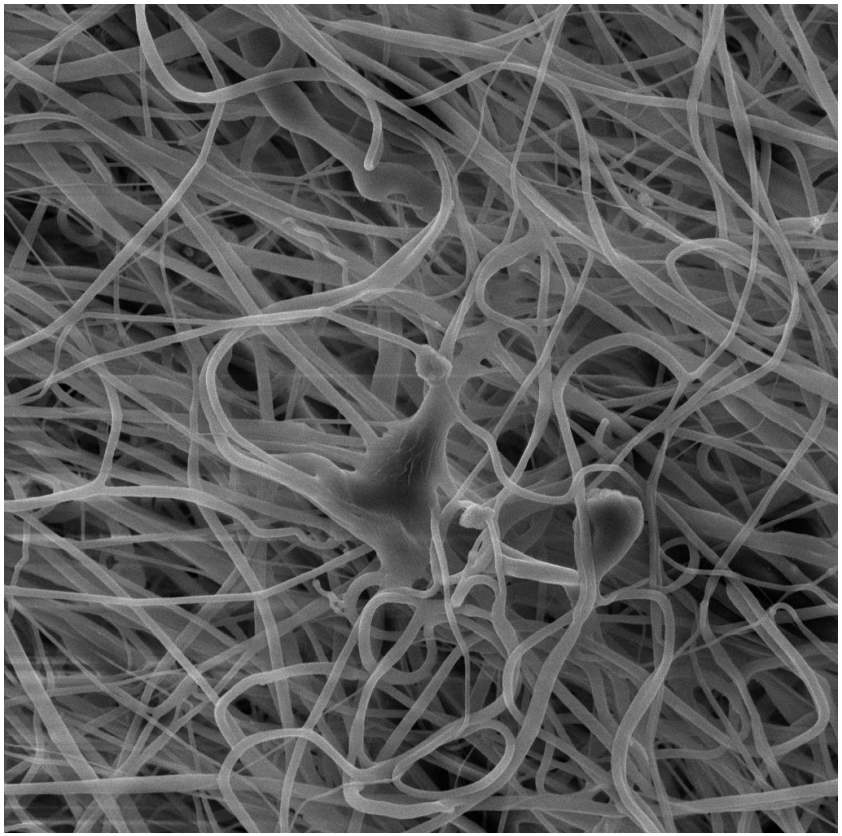
Nanofiber
Two dimensions at the nanoscale



Nanoplate
One dimension at the nanoscale

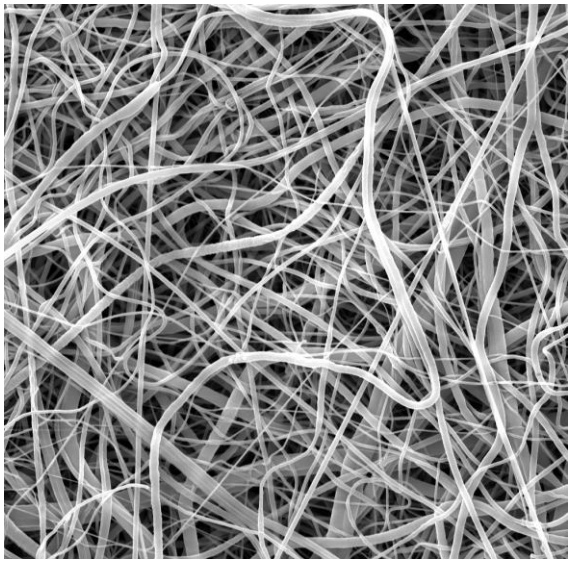

0,1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
1 cm
10 cm

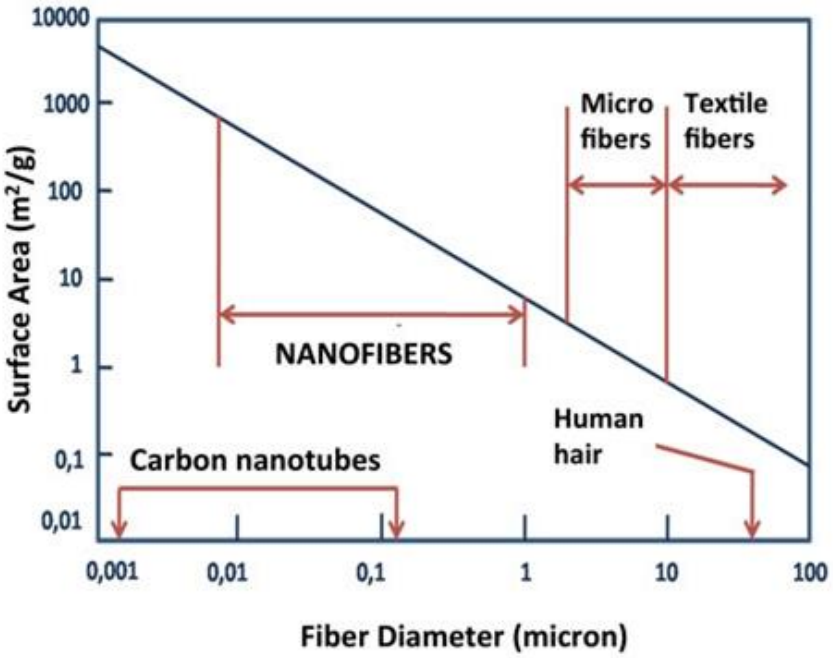




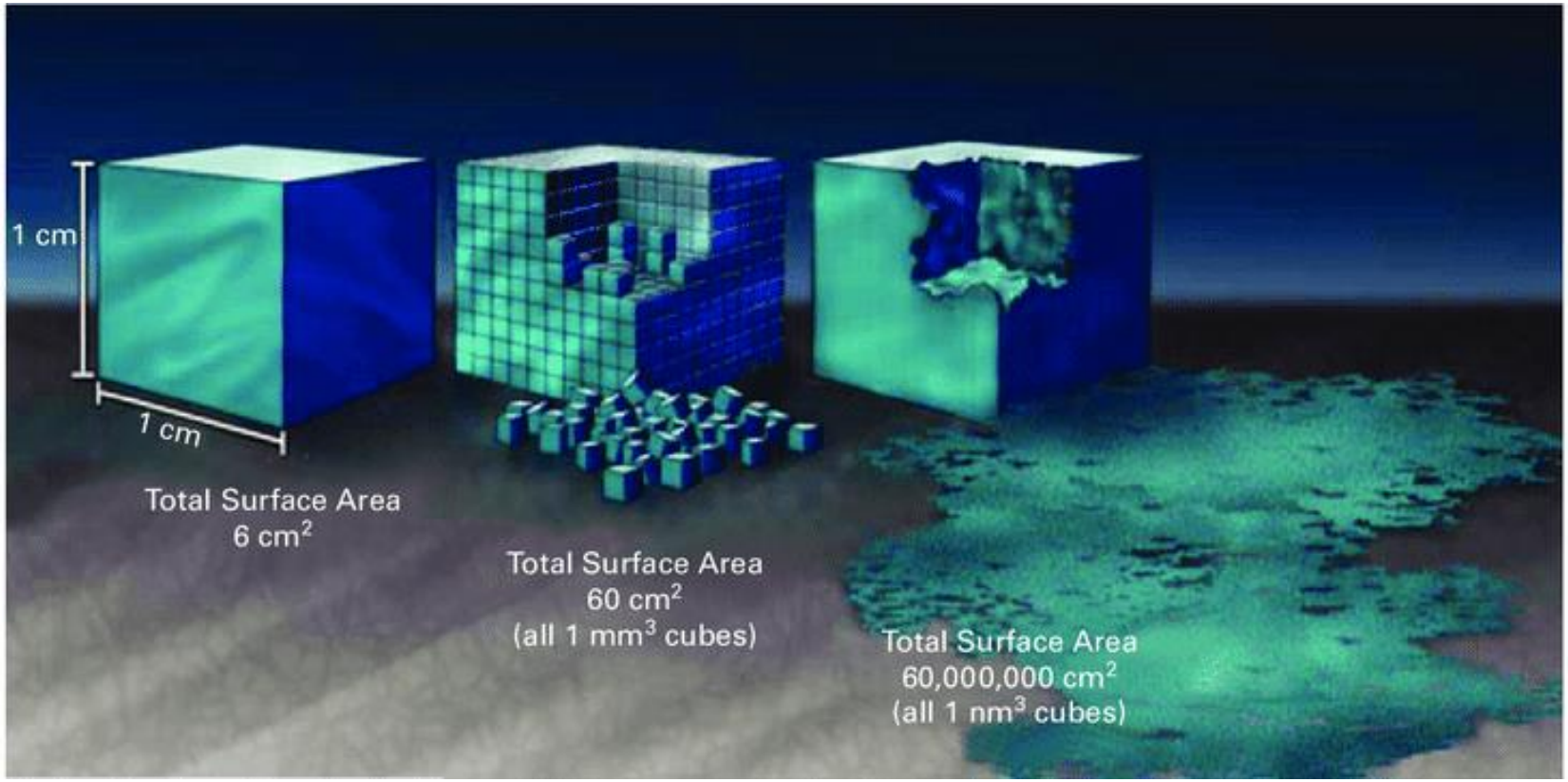
Why nanofibers?

- High porosity
- Small pore diameter
- Large specific surface



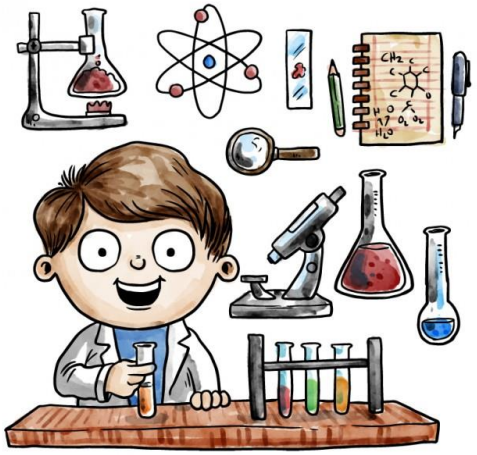


Specific surface



What do nanofibers come from?

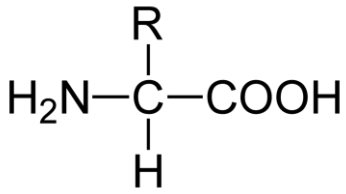
- From natural and synthetic materials
- From homopolymers, copolymers
- From blends
- From solutions or melts



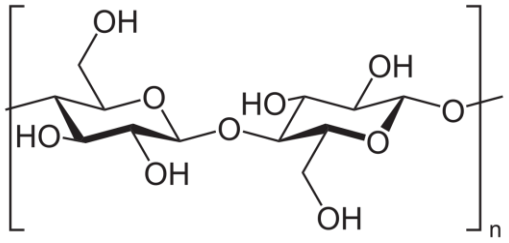
- It was electrospun more than 100 different polymers

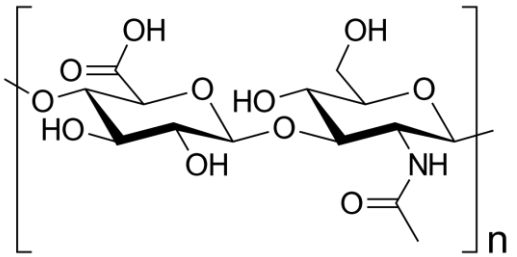
Natural materials

- Proteins - composed of amino acids
  - Collagen
  - Gelatin
  - Elastin



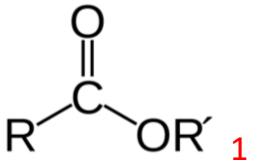
- Polysaccharides - composed of saccharide units
  - Hyaluronic acid
  - Starch
  - Cellulose
  - Alginate
  - Chitosan





Synthetic materials

- Polyamides - PA 6, PA 66
- Polyesters - PET, PCL, PLC, PHB, PLA, PLGA,…
- Polyurethanes
- Polyethers - PEO
- Polyvinyls - PVA, PVB, PAN
- Polyolefins - PE, PP



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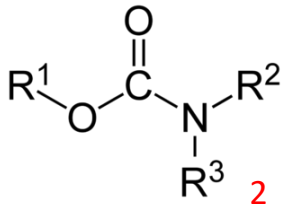

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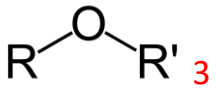

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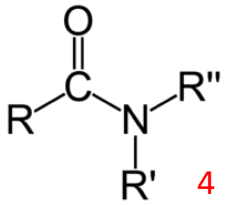

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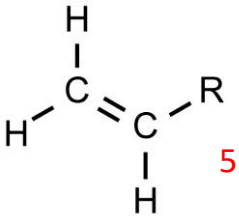

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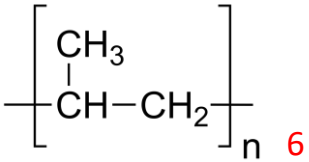

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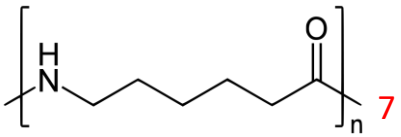
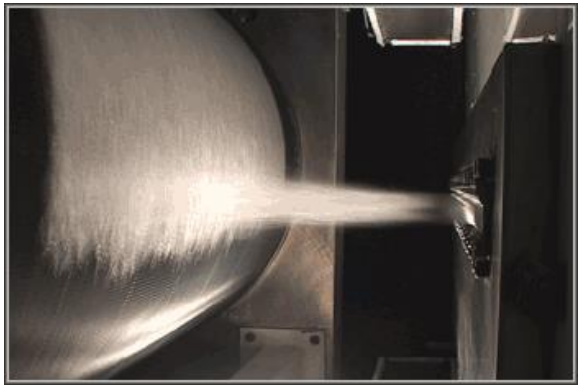
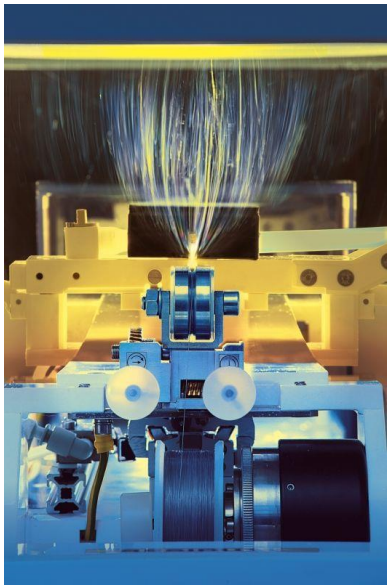


7

How are nanofibers formed?

- Electrospinning
- Meltblown
- Centrifugal spinning
- Bicomponent fibers

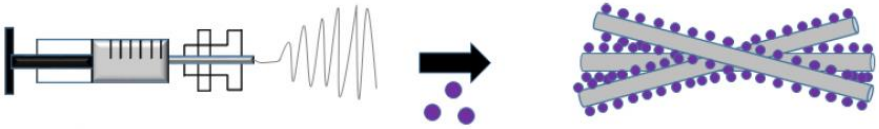




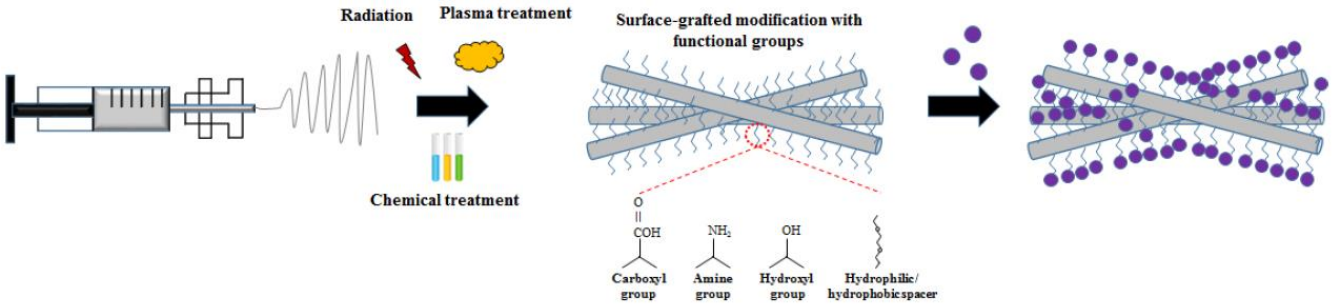
- Drawing
- Synthesis template
- Phase separation
- Self-assembly
- Freezing

Modification of nanofibers

- Physically



- By grafting
  - Plasma
  - Radiation
  - Chemical

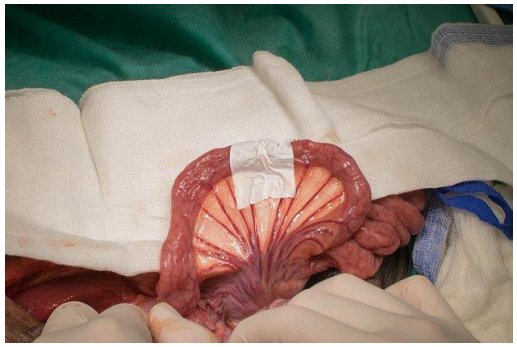


- By adding additives

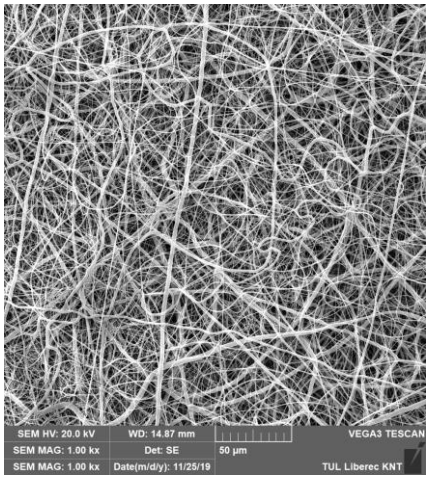
- Coaxial spinning

What are nanofibers suitable for?

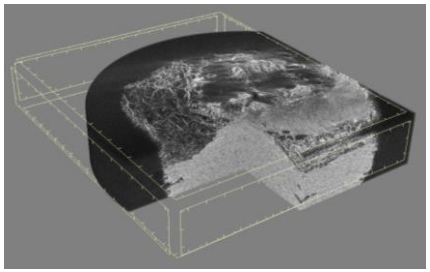
- Filtration
- Tissue engineering
- Optical sensors
- Sound isolation
- Battery
- Clothes
- …

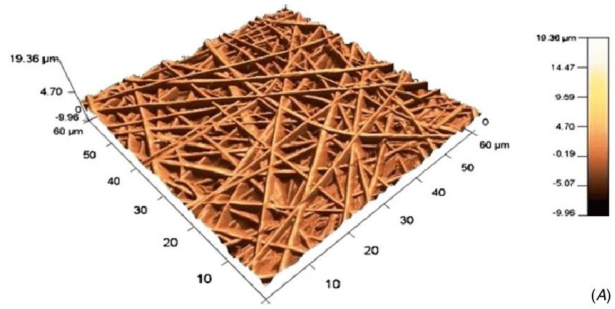


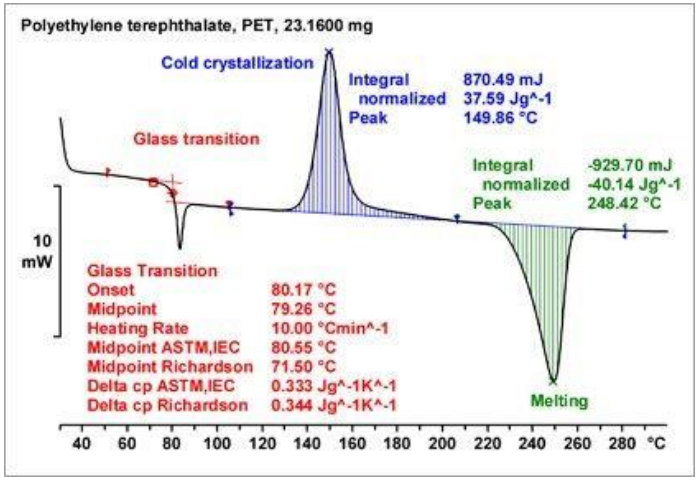
How can nanofibers be characterized?



- SEM / TEM - electron microscopy
- AFM - three-dimensional representation of the surface
- TGA / DSC - thermal analysis
- BET - measurement of specific surface
- XPS - chemical composition
- CT - model acquisition





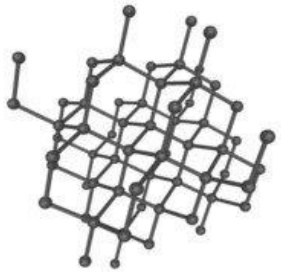


Carbon nanomaterials

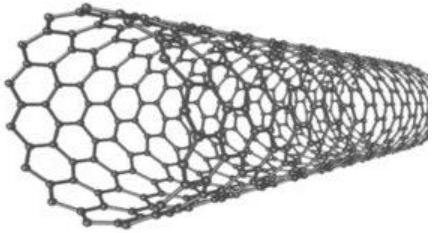
- Carbon - a chemical element, the cornerstone of all organic compounds

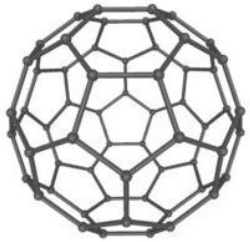
- Occurrence of carbon:
  - Free carbon
  - Organic compounds
  - Inorganic compounds

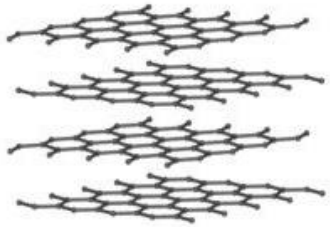
Forms of carbon



- Diamond - a crystalline form of carbon
- Graphite - layers of graphene that hold together under the influence of van der Waals forces
- Graphene - carbons bound in hexagons
- Fullerenes - layers of five and hexagons, rolled into a "spherical" shape
- Nanotubes - cylindrically coiled graphene layers
- Nanofibers

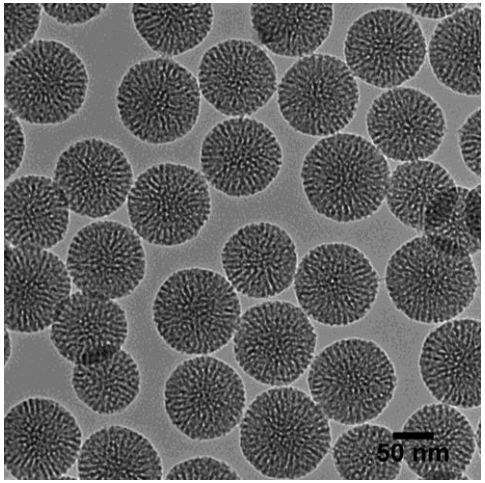


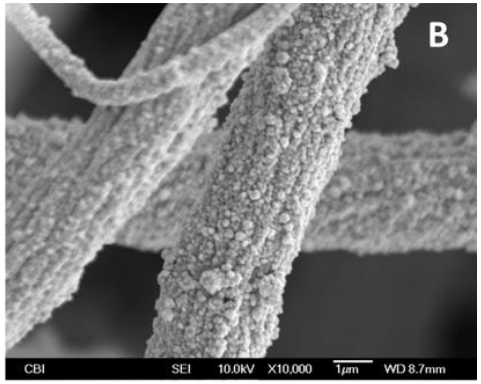




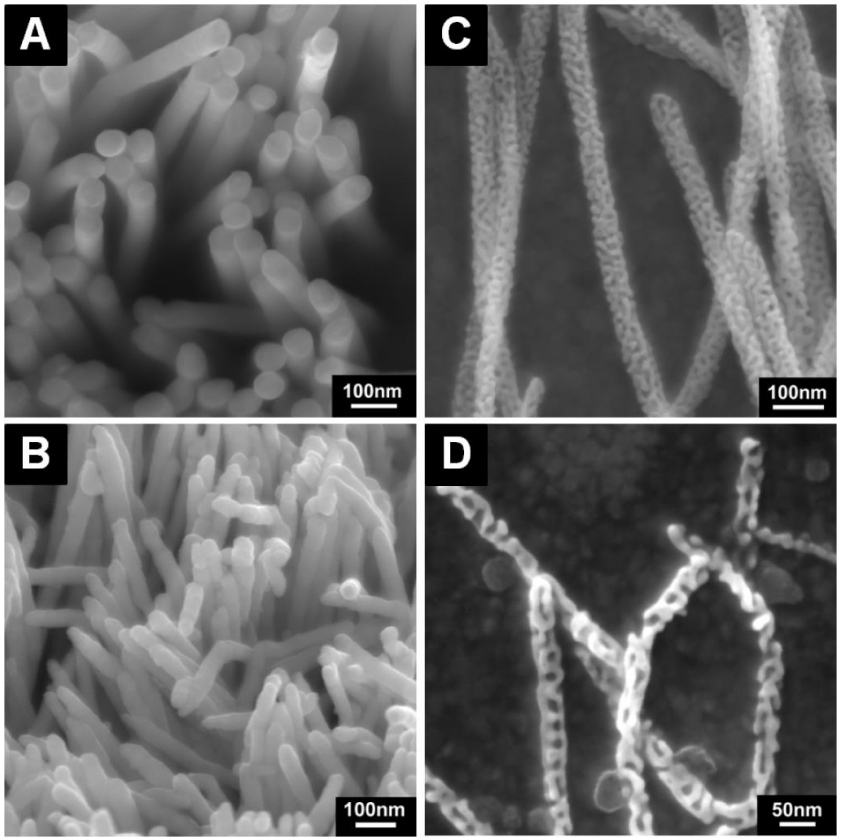
Inorganic nanoparticles

- Nanoparticles of metal oxides - TiO_2, Al_2O_3, ZrO_2, MnO, CeO_2
- Magnetic nanoparticles - Fe_3O_4, Fe_2O_3
- Silica nanoparticles - SiO_2
- Silver nanoparticles
- Gold nanoparticles

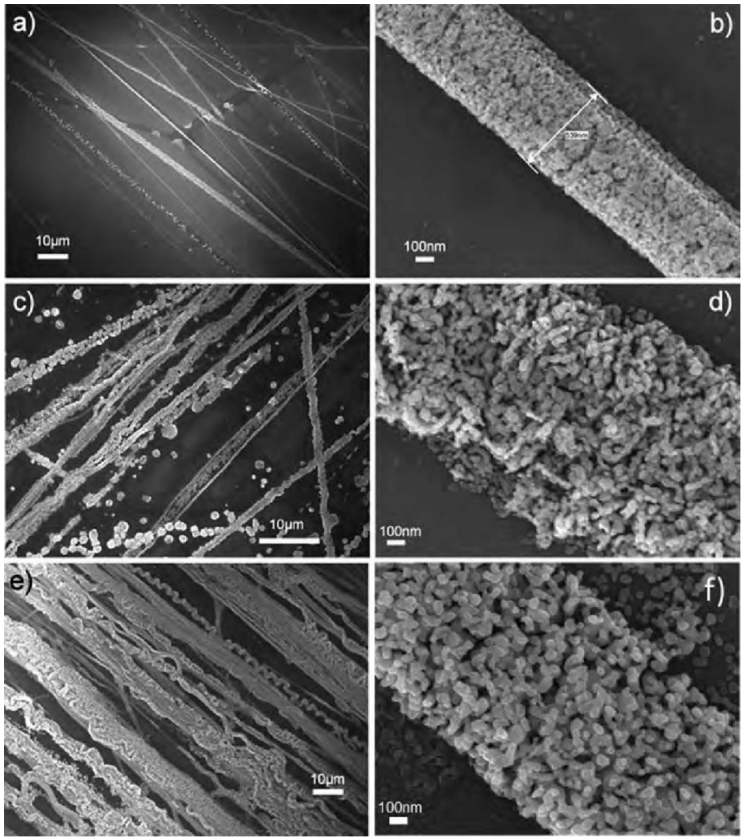




Inorganic nanofibers

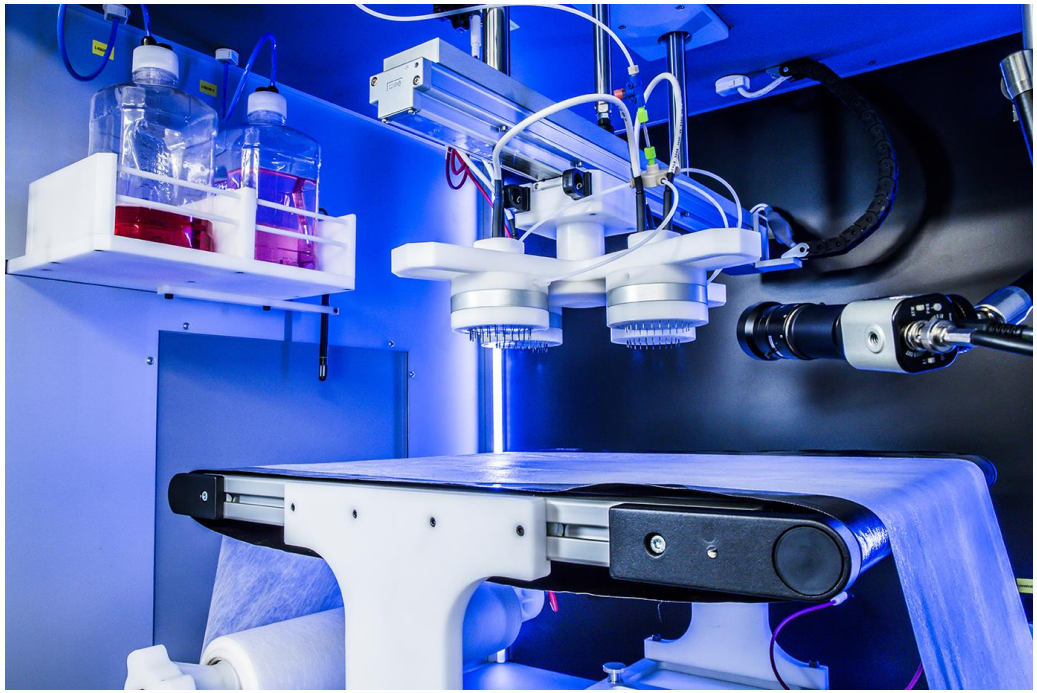


SEM images of the AuAg alloy nanofibers of different diameters of (A) ~55 and (B) ~43 nm and their corresponding p-Au nanofibers ((C) and (D)) after Ag etching, respectively.



SEM images of the electrospun copper oxide nanofibers obtained with different amounts of initial copper nitrate: 6, 9 and 12 g in the first, second and third row, respectively.

Thank you for your attention!



TEST

What are the dimensions of nanofibers?

What technologies can be used to prepare nanofibers?

What are carbon nanomaterials?