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Nanofibrous materials

from polymeric solutions to their applications

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ETPN Webinar | 29th November, 4 pm | Contipro a.s.

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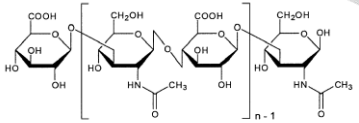
CONTENTS

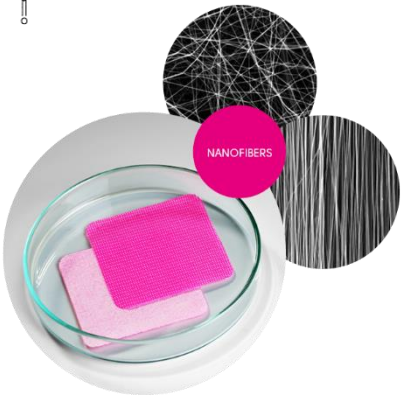
R&D AT CONTIPRO

- Tissue engineering
- Anti-aging of skins
- Drug delivery systems
- Regenerative medicine
- Wound healing
- Nanotechnology

- Forms of hyaluronan
  - Hydrogels
  - Microfibers
  - Polymeric micelles
  - Nanofibers

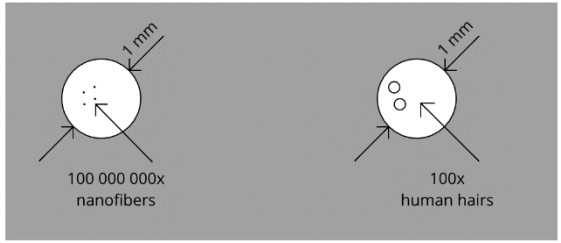


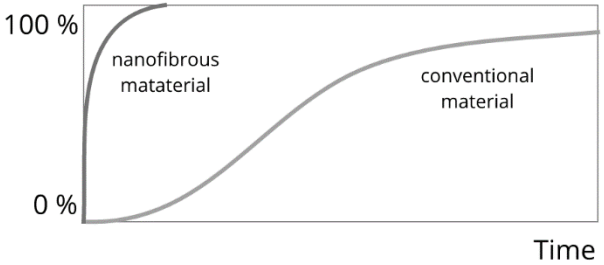
Hyaluronan

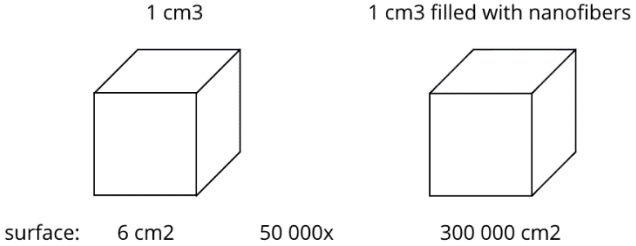


WHY NANOFIBROUS MATERIALS

- Small diameter
- High surface-to-volume ratio
- Intensive and rapid interactions
- High porosity
- Small pore size







RAW MATERIALS & SOLUTIONS

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- Natural and synthetic polymers
- Biocompatible and biodegradable
- Hyaluronan (LMW, HMW, derivatives)

HA derivatives	Natural polymers	Synthetic polymers
Furanyl	Gelatin	PEO
Metakryloyl	Collagen	PA6
Thiofen	Alginate	PU
Cinnamoyl	Chitosan	PVA
Oleyl	Cellulose	PVP
Palmitoyl	Dextran	PLGA
		PCL
		PA66
		PAN
		PLLA
		PA
		PDLA
		Nylon 6
		Oxycellulose
		Carboxymethyl Cellulose
		poly(TFE-co-HFP-co-VDF)

- Materials research of nanofibers is based on strong background of chemical syntheses and polymer science.
- More than 25 of raw materials and their derivatives from the group of natural and synthetic polymers have been electrospun into form of nanofibers by 4SPIN® technologies so far.
- These materials have become to be a substantial support for regenerative medicine and tissue engineering applications research.

WHY ELECTROSTATIC SPINNING

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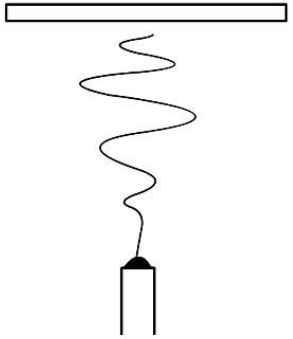
- Transfer dissolved polymeric powders into nanofibers of various shapes and order

Pros
- Variability
- Scalability
- Application adaptability
- Additives incorporation

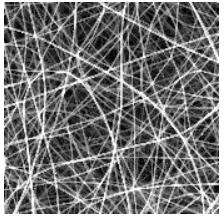
Cons
- Multivariable process
- Low throughput
- Low homogeneity

Polymer powder

Solution



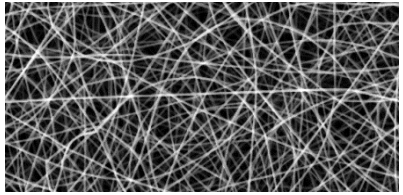
Electrostatic spinning

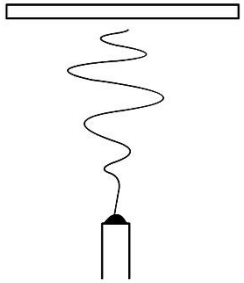


Nanofibrous materials

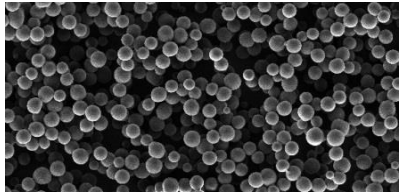
4SPIN® TECHNOLOGIES

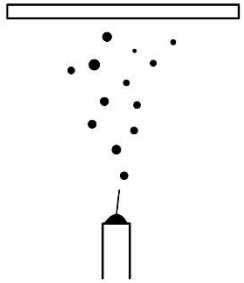
- Core technologies & techniques



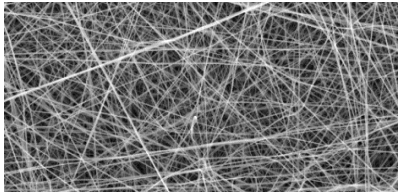


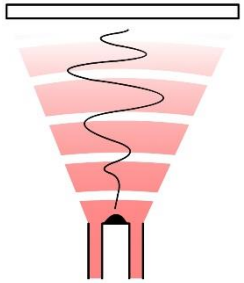
Electrospinning



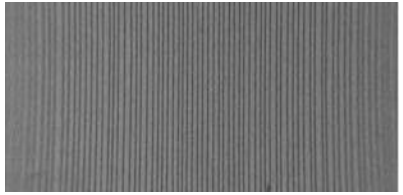


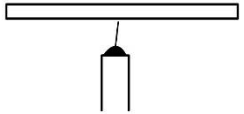
Electrospraying





Electroblowing





NF Electrospinning

4SPIN® TECHNOLOGIES

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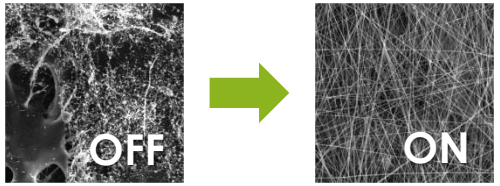
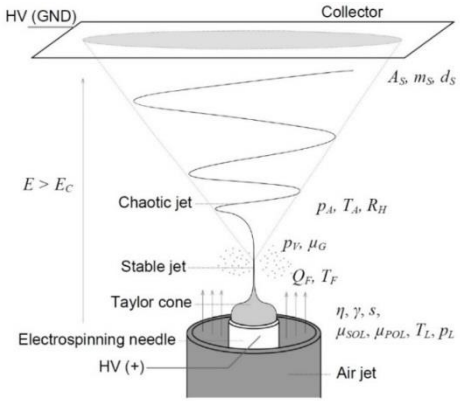
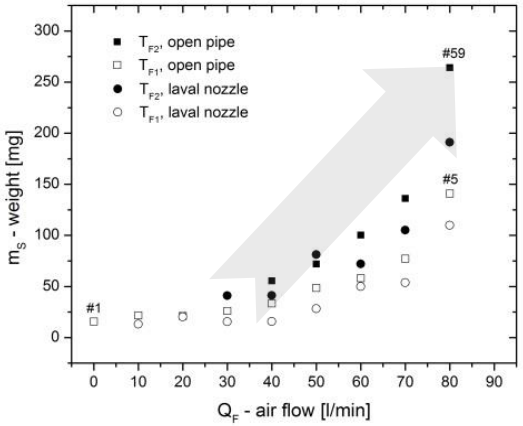
- Benefits of using electroblowing (hot airflow):
  - Simply avoid wet/defect samples by switching it on
  - Is the most suitable method for HA (natural polymers) nanofibers production







Increased production of nanofibrous materials by electroblowing from blends of hyaluronic acid and polyethylene oxide, *Polymer Engineering & Science*, Vol. 56, Issue 8, August 2016, p. 932-938

4SPIN® TECHNOLOGIES

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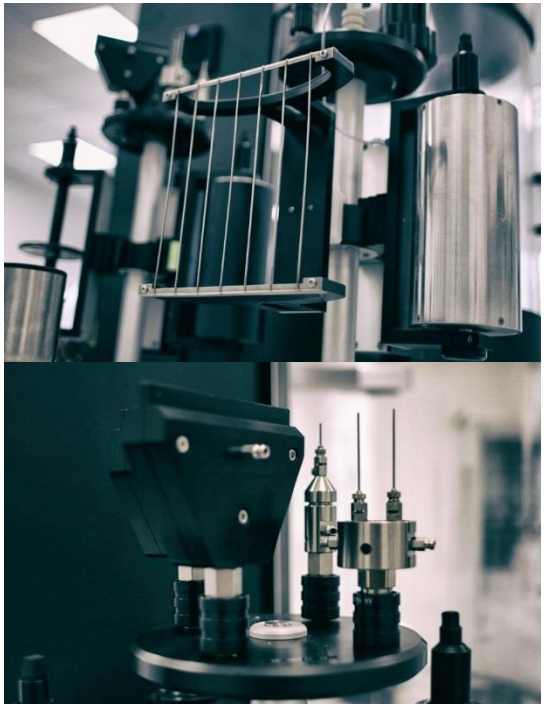

4SPIN® LAB - multifunctional laboratory device

Laboratory device for the manufacture of nanomaterials, *Nanomaterials and Nanotechnology Journal*, 2015, 5:17, June 5

4SPIN® TECHNOLOGIES

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- Accessories - emitters

UNICOMPOUND

Single jet

Multi jet

Needleless rod

Multi needleless

Linear multi needleless

*EBR = Electroblowing ready

COMPOSITES

Double jet

Needleless rod

Multi needleless

Coaxial single jet

- Variety of accessories for these devices is available comprising electrodes for specific depositions, holders and tools for soft material manipulations, fast quality check tools, etc. Custom components for 4SPIN® devices were and are being developed according to customer specifications.

4SPIN® TECHNOLOGIES

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- Accessories - collectors

Static continual

Static patterned

Rotating continual

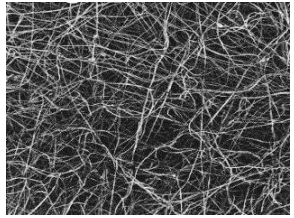
Rotating patterned

Tube collector

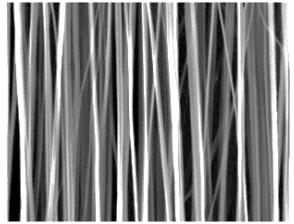
Rotating thin disc

Endless belt

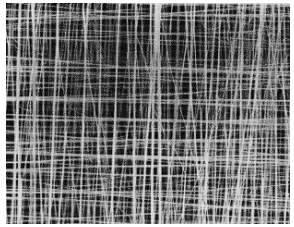
*ANFD = Aligned nanofibers deposition



RANDOM



ALIGNED



CROSSED

- Layers with random & aligned structure, other 3D shapes
- Large sheets of nanofibers up to 100 x 25 cm^2

4SPIN® TECHNOLOGIES – SCALE UP

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4SPIN® Roll-to-roll manufacturing device

- Semi-industrial scale device for production of large sheets (width is up to up 60 cm)
- Production speed of HA nanofibers is up to 10 g/h

FORMS & STRUCTURES

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- Nanofibers of different structures are deposited in order to meet different applications criteria

Alignment	Random & regular
Compound	Unicompound, blended, composites, additives, coaxial
Morphology	Endless fibers, spheres, mixtures
Layers	Low area weights (thin), high area weights (thick), large & homogenous, self supporting, touched on a substrate
Macroscopic	large sheets, hollow tubes, yarns, stacked layers, pillows

TARGETED APPLICATIONS

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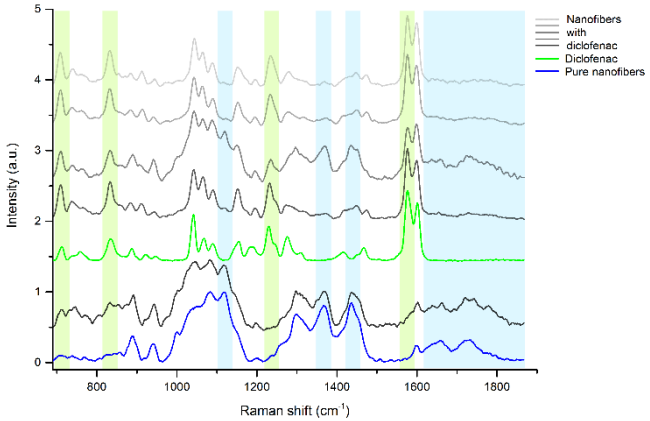
TARGET: Patches based on nanofibrous material for cosmetic applications

RESULTS: Hyaluronan nanofibers with variety of different types of additives



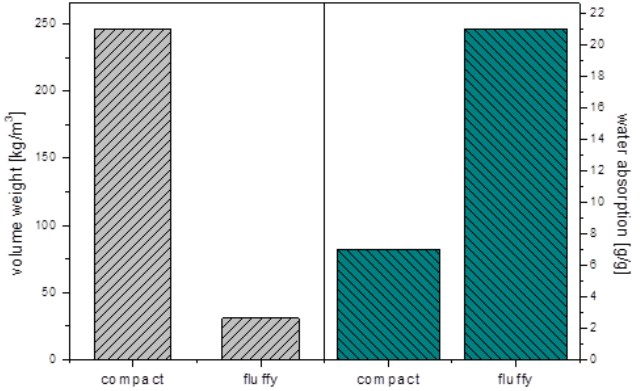
Fabrication and Characterization of Hyaluronic Acid/Poly(ethylene) Oxide Nanofibres, *Polymer*, Under decision
Raman Spectroscopy Analysis of Biodegradable Electrospun Nanofibers Prepared from Polymer Blends, Monatshefte für Chemie - Chemical Monthly, Vol. 147, Issue 5, May 2016, p. 919-923
Raman spectroscopy based method for the evaluation of compositional consistency of nanofibrous layers, Analytical Methods, Vol. 7, Issue 23, Nov 03, 2015, p. 9900-9905

TARGETED APPLICATIONS

TARGET: Highly adsorable material for wound dressing

RESULTS: Voluminous & high areal weight pillows made of HA nanofibers

- Great sorption ability suitable for the treatment of chronic wounds
- Such medical device assures a moist wound healing with all its benefits and it may also release antimicrobial substances eliminating the wound contamination

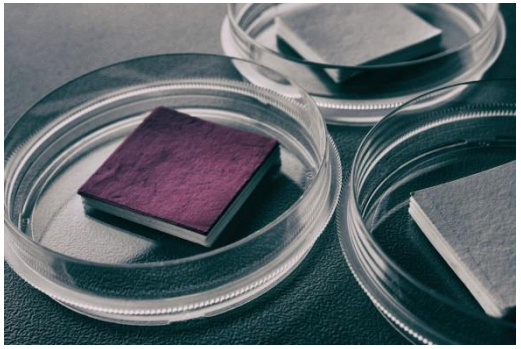


Intracellular delivery II: Hyaluronic acid based nanofibers for wound dressing and drug delivery carriers. Dordrecht : *Springer Science+Business Media Dordrecht*, 2014. Vol. 2, Chap. 20, 417-433. ISBN: 978-94-017-8895-3

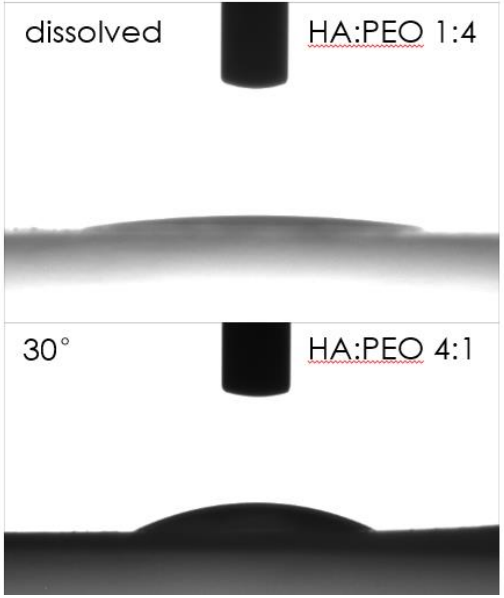
TARGETED APPLICATIONS

TARGET: Patches based on nanofibrous material for oral cavity use

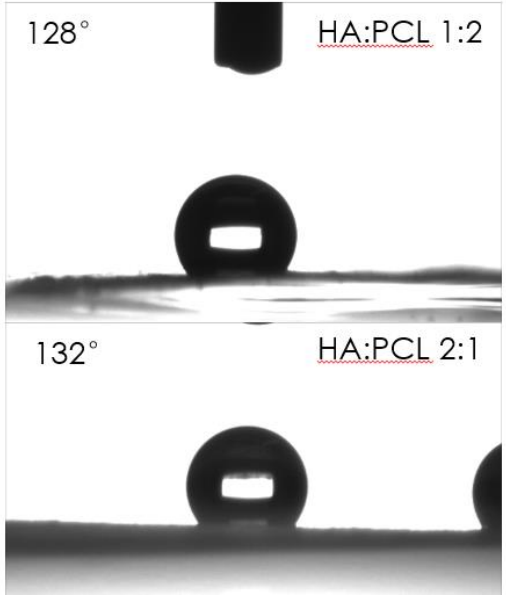
RESULTS: Hyaluronan/PCL nanofibers with hydrophobic and hydrophilic surfaces



Hydrophilic



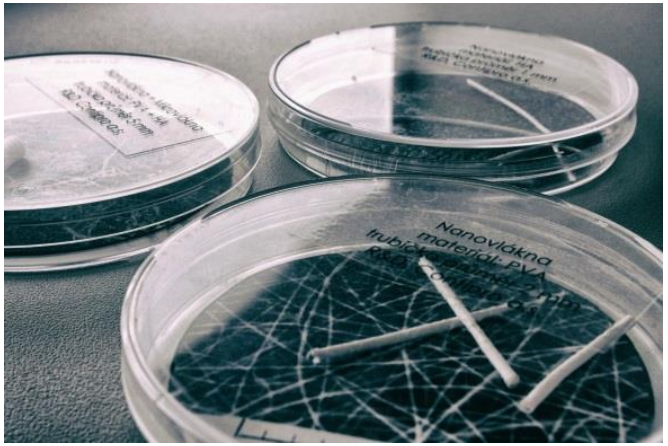
Hydrophobic



TARGETED APPLICATIONS

TARGET: Nanofibrous hollow tubes for vascular grafts

RESULTS: Tubes with inner diameter from 1 to 7 mm made of synthetic polymers



TARGETED APPLICATIONS

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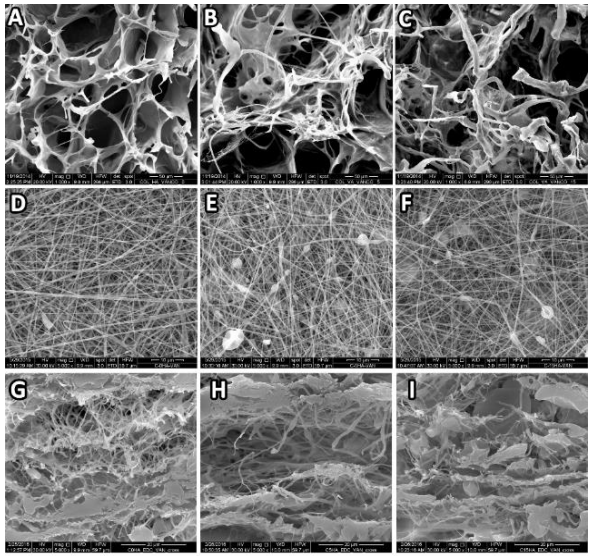
TARGET: Functionalized implant prevents inflammatory reactions

RESULTS: Collagen/Hydroxyapatite Nanostructured Layers deposited on Ti implants



The Czech Academy of Sciences

Department of Composites and Carbon Materials
Institute of Rock Structure and Mechanics

ProSpon

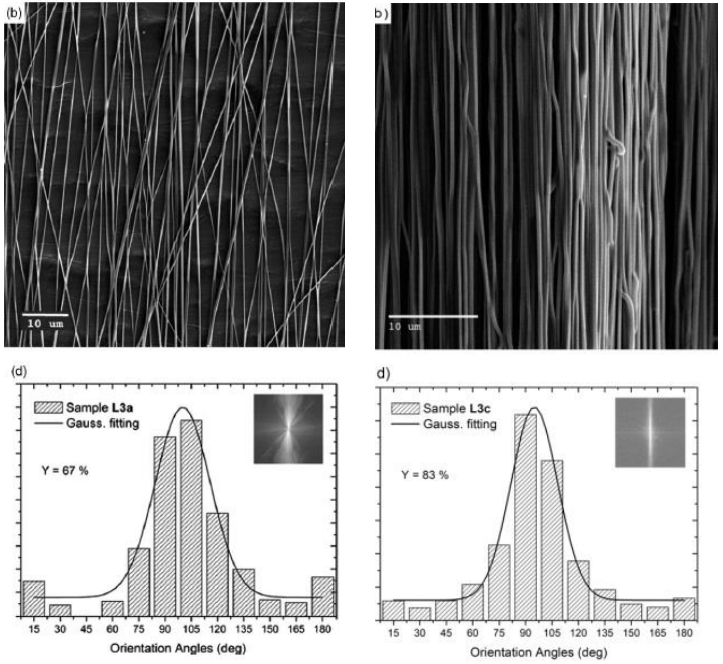
The Art of Technical Surgery

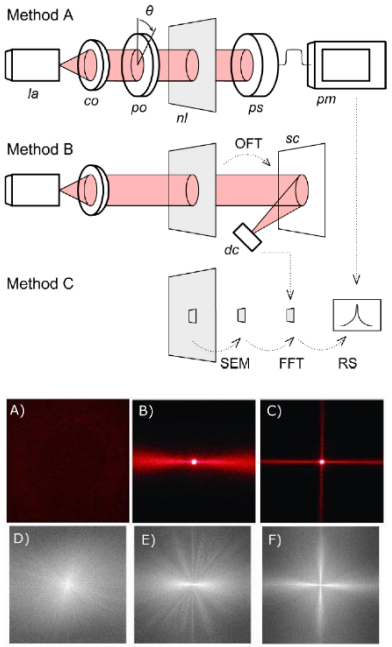
The Release Kinetics, Antimicrobial Activity and Cytocompatibility of Differently Prepared Collagen/Hydroxyapatite/Vancomycin Layers: Microstructure vs. Nanostructure, *Journal of Controlled Release*, Under decision

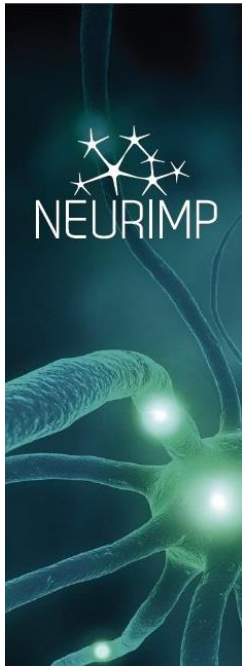
TARGETED APPLICATIONS

TARGET: Neural tissues applications including directional neuronal growth

RESULTS: Aligned nanofibers into one direction





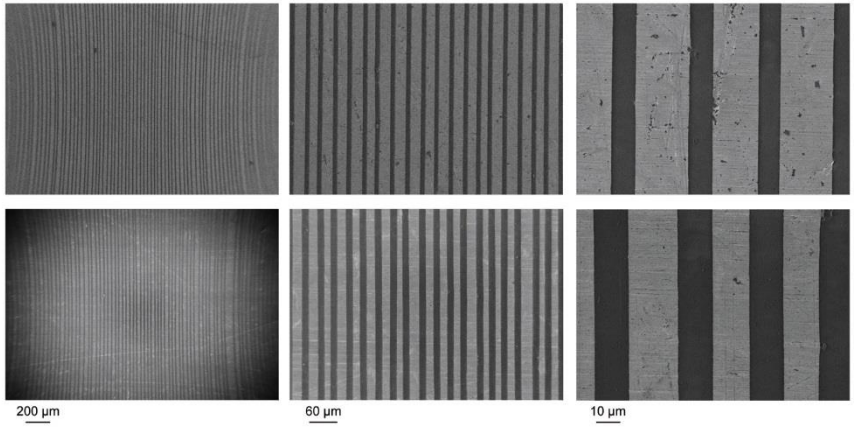


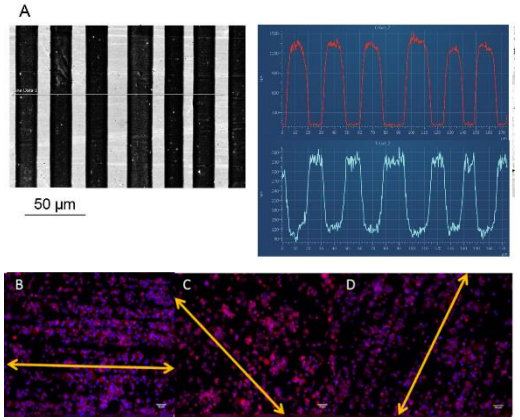
Collection Method for Extra Aligned Nanofibers Deposited By Electrospinning, *Review of Scientific Instruments*, 2011, Volume 82, Issue 5, May 20, 2011, p.055112
Transversal electrostatic strength of patterned collector affecting alignment of electrospun nanofibers, *Applied Physics Letters*, Volume 96, Issue 19, 13 May 2010, p.193111-1, 193111-3
Non-invasive optical method for rapid determination of alignment degree of oriented nanofibrous layers, Review of Scientific Instruments, 86, 106111 (2015)

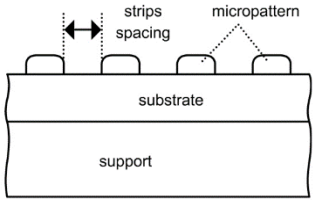
TARGETED APPLICATIONS

TARGET: Surfaces modification for implants with immunomodulatory functions

RESULTS: Precisely distributed parallel strips prepared by near-field electrospinning







immodgel

Innovative Immunomodulatory Implants

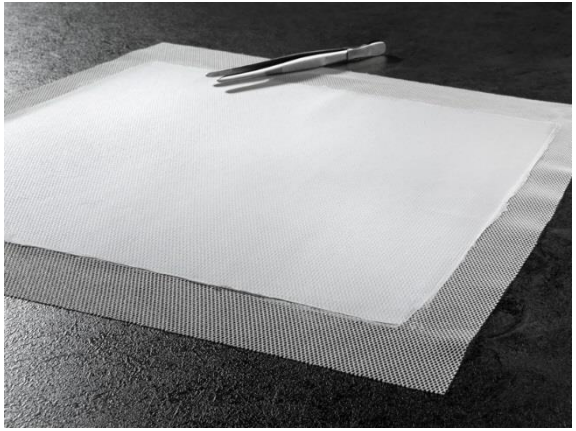
Electrohydrodynamic printing as a method to micropattern large titanium implant surfaces with photocrosslinkable structures, *Biomedical Physics & Engineering Express*, In press

QUALITY CONTROL

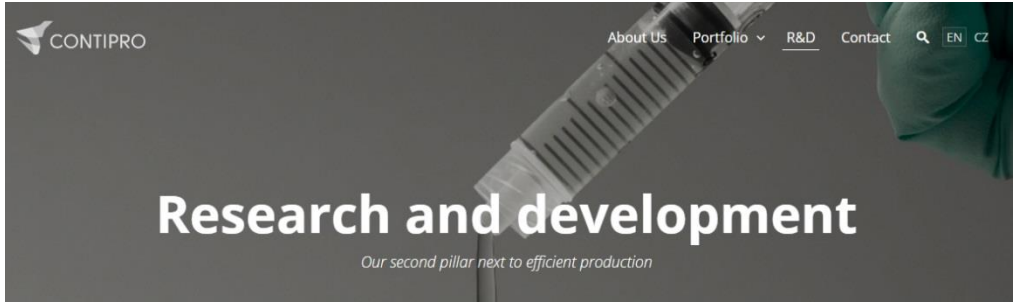
- Overall parameters
- Structural
- Chemical
- Mechanical

Varieties of analyses are provided in order to ensure the high quality of products. It means the structural, chemical, mechanical and overall parameters are checked using advanced scientific methods such a:

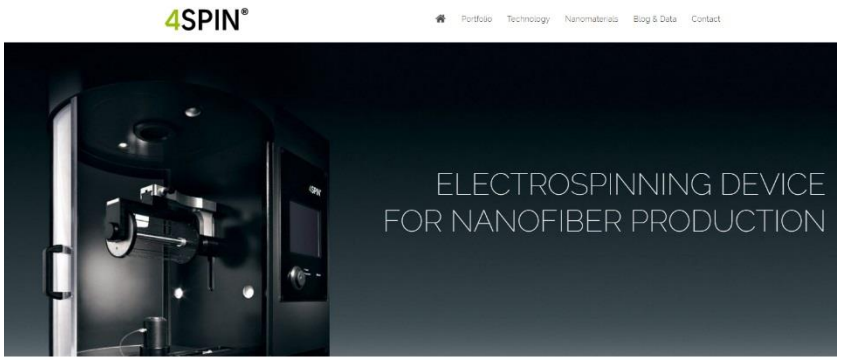
- scanning electron microscopy
- confocal Raman spectroscopy
- energy-dispersive X-ray spectroscopy
- thermal analysis
- FT infrared spectroscopy
- contact angle measurement
- tensile tests
- transmission and diffraction light analysis
- etc.



FIND OUT MORE



http://contipro.com/r-and-d



https://www.4spin.info/

https://youtu.be/40W-WABZJaY

https://youtu.be/M_V3MRjskTQ

Trial tests are available for research of other R&D teams right in our laboratories on our technologies and with our knowledge support. We are open for students intern as well.

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THANK YOU FOR YOUR ATTENTION

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