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**



# KNT_TNA_Electrospinning 2

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NextGenerationEU

CZECH RECOVERY PLAN

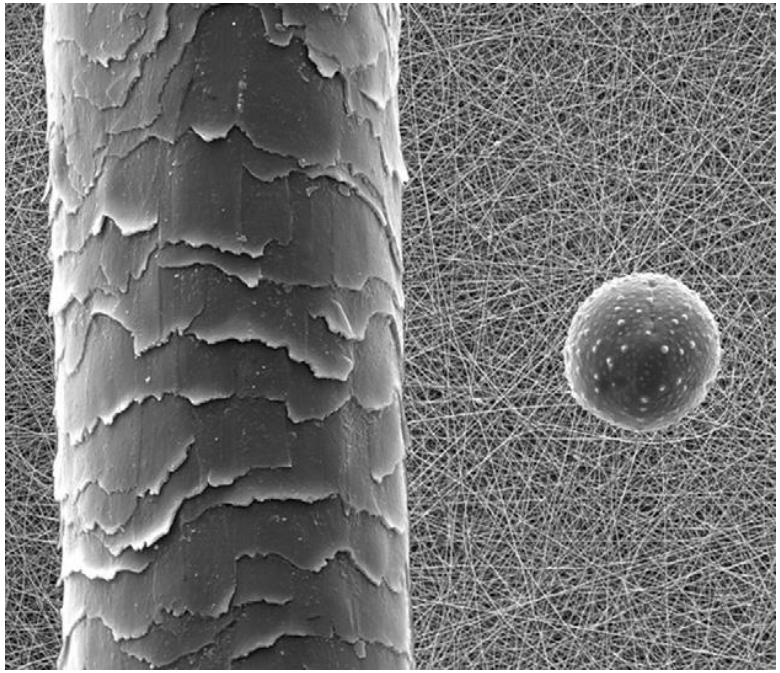
MINISTRY OF EDUCATION, YOUTH AND SPORTS

# Repetition

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

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

Nanofibers – up to 1000 nm



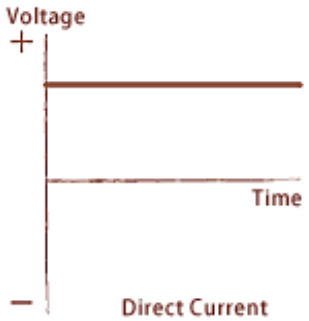
- High porosity
- Small pore diameter
- Large specific surface

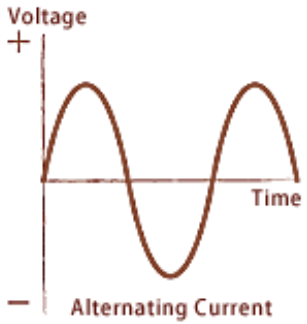
# Repetition

- The process of fiber formation by the effect of an electric field
- Described as tugging between electrical and capillary forces

- High voltage DC power supply
  - It does not change its polarity over time
  - Positive / negative

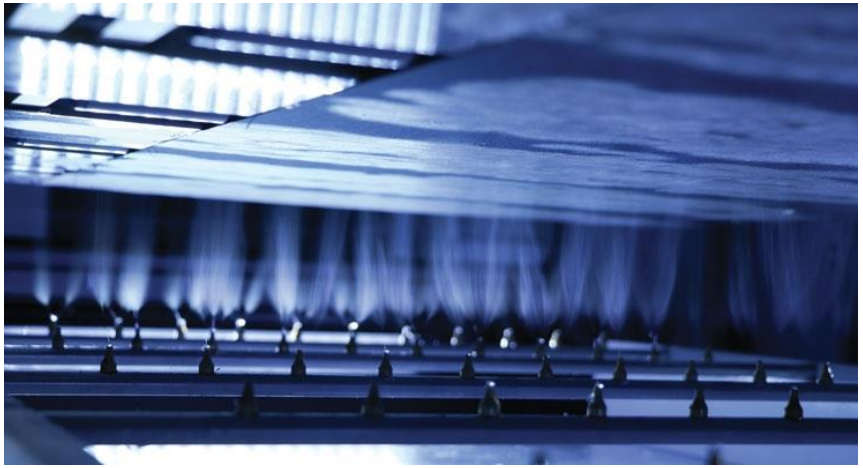
- From solutions or melts



# Repetition

Needle electrospinning



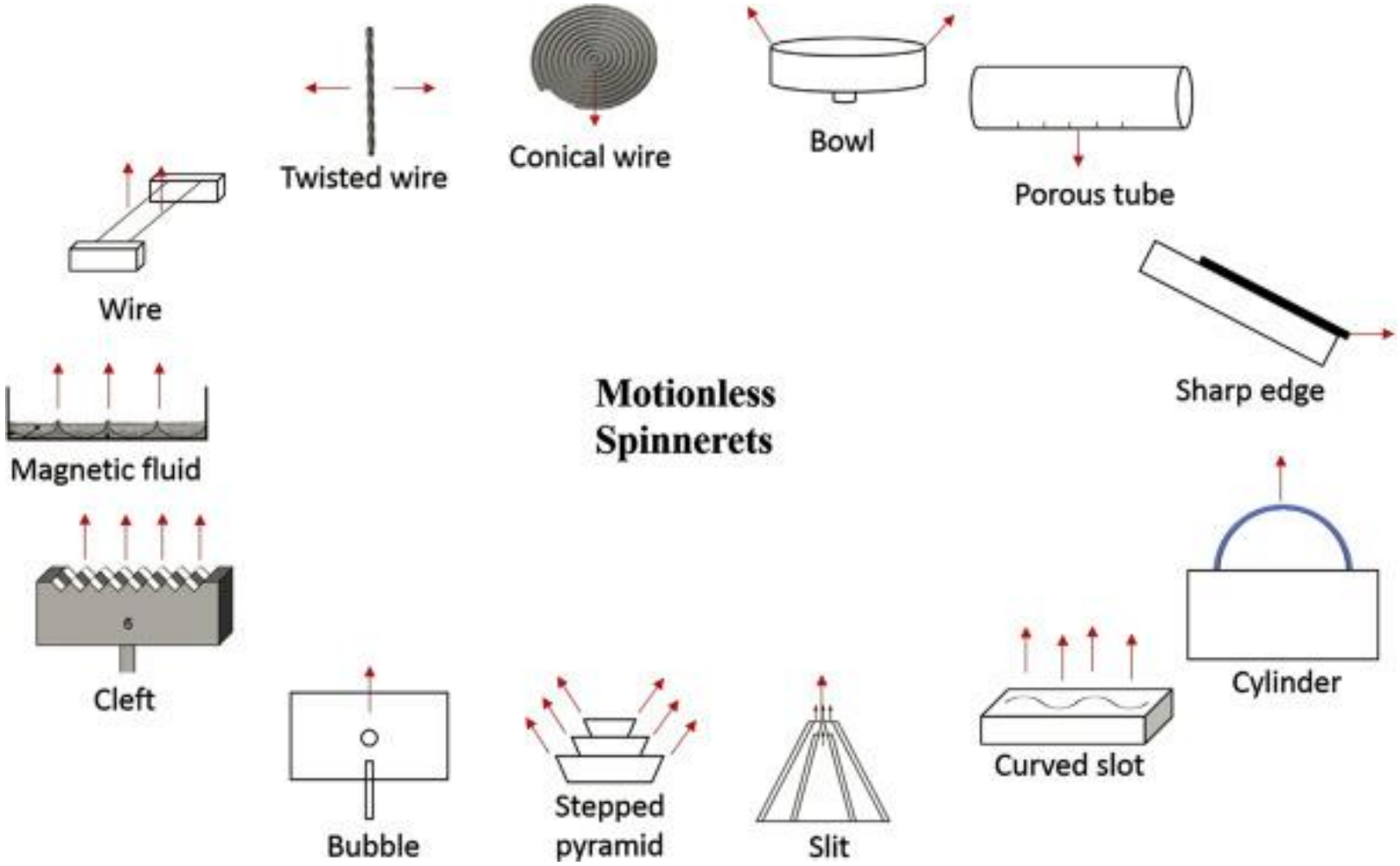
Needle-less electrospinning

Electrode - charged / grounded

Collector - charged / grounded

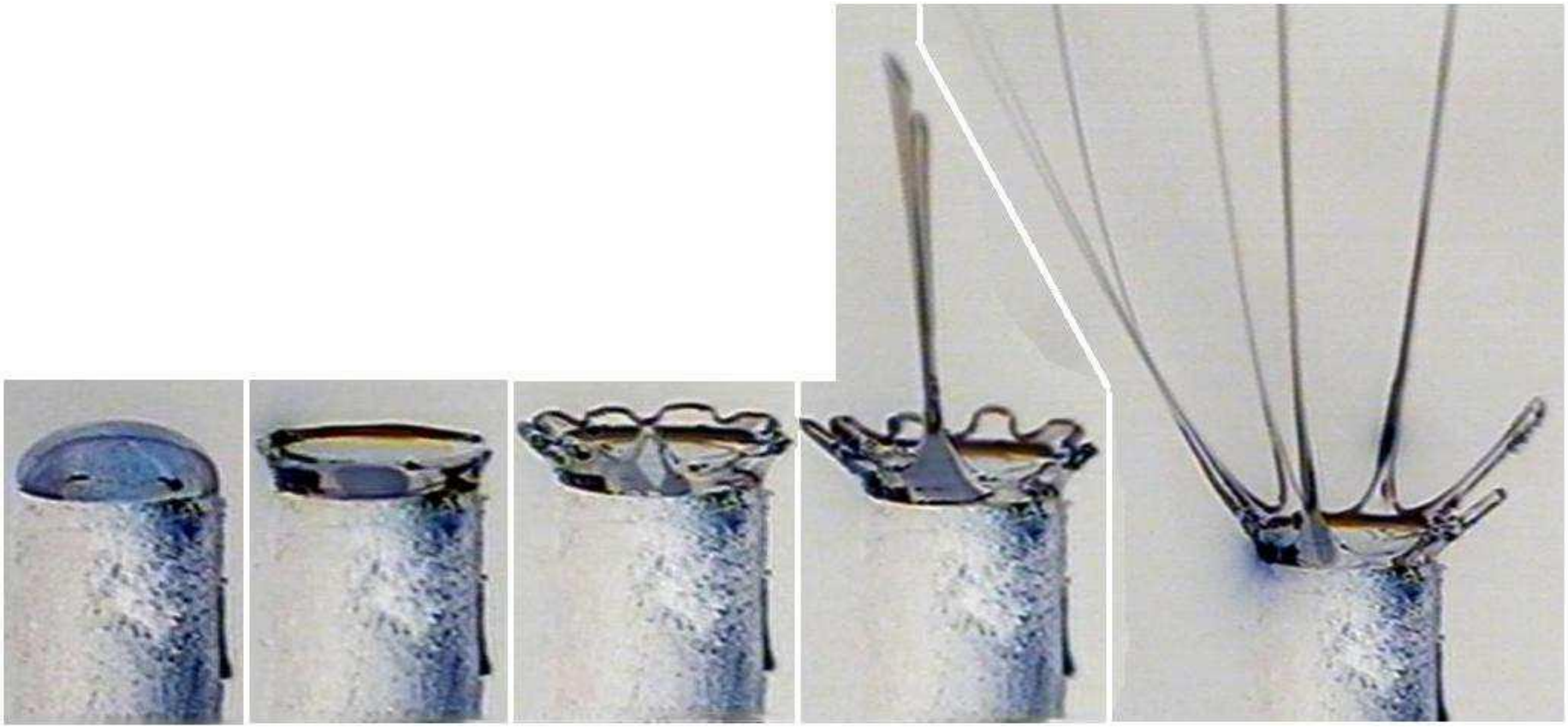
# Electrospinning 2

# Needle-less electrospinning

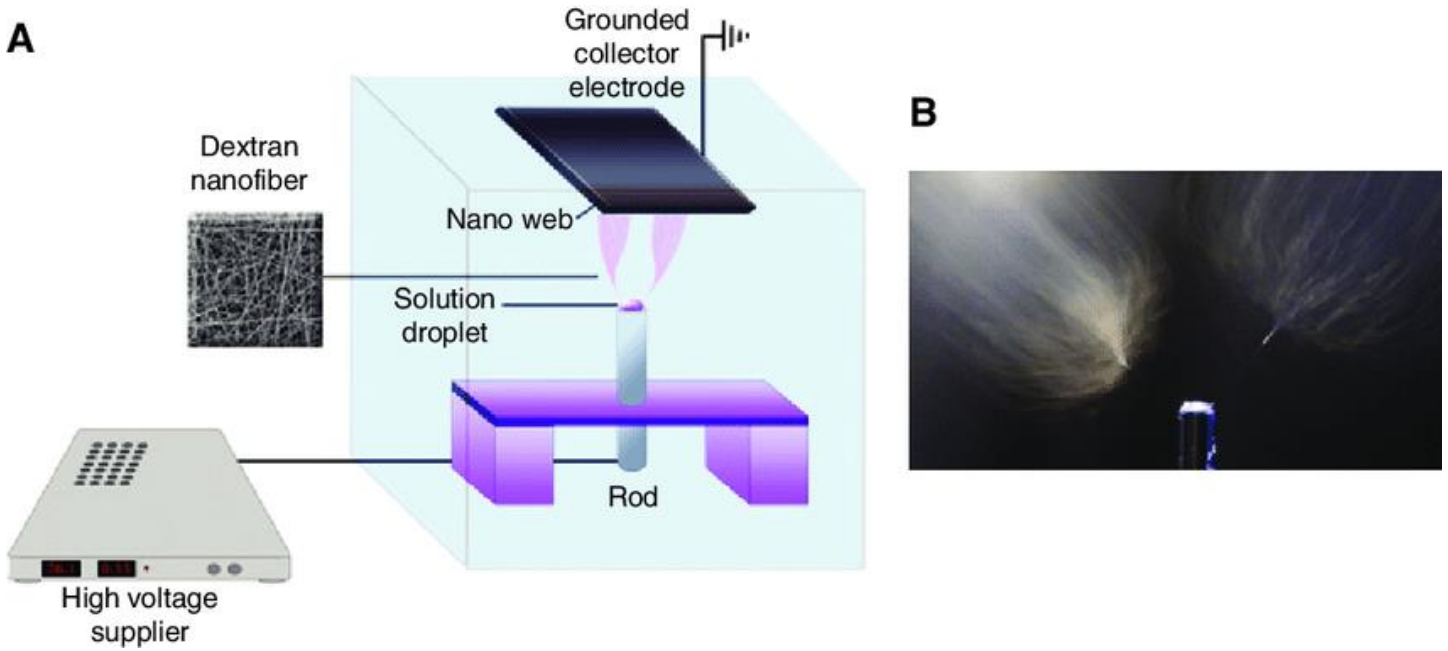


# Needle-less electrospinning

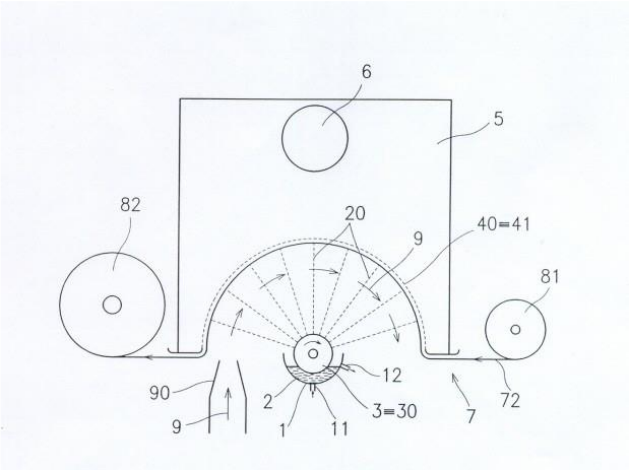
- Self-organization of the solution into a Taylor cone, a stable part, a whipping part and evaporation of the solvent
- The individual nozzles are formed without the need for a capillary
- Increasing the productivity of the production of nanofiber layers

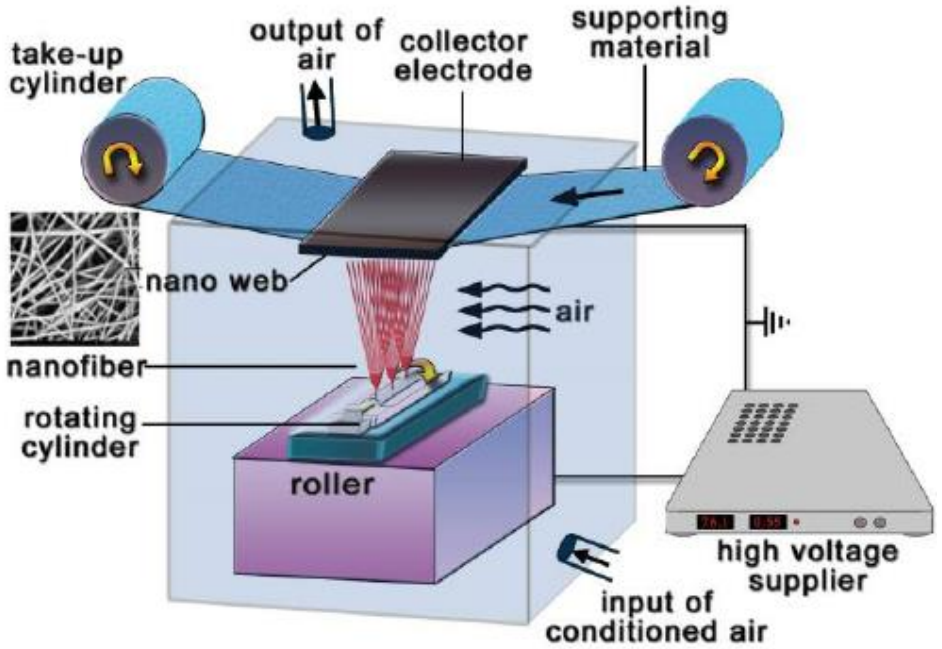


# Needle-less electrospinning - rod



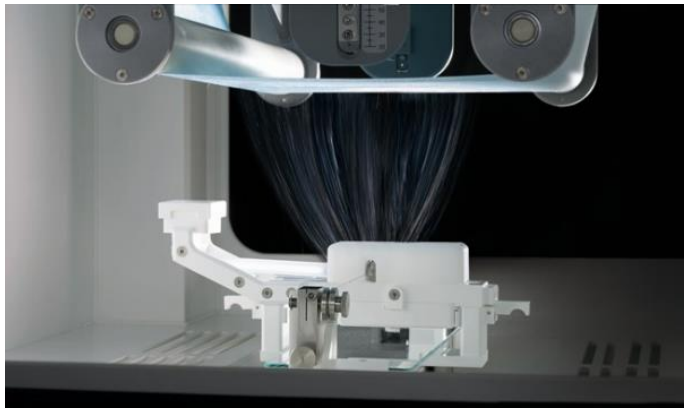
# Needle-less electrospinning - roller

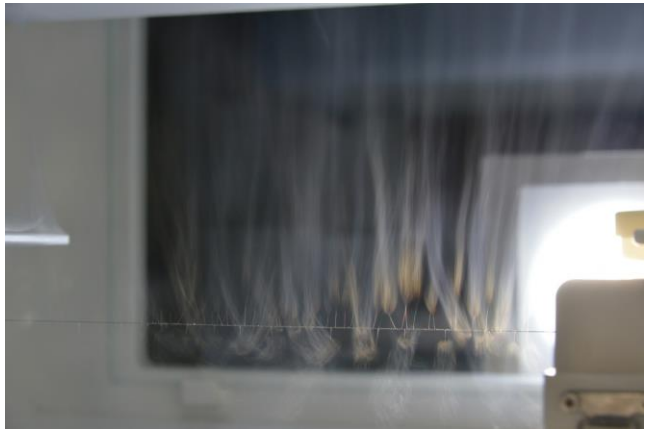


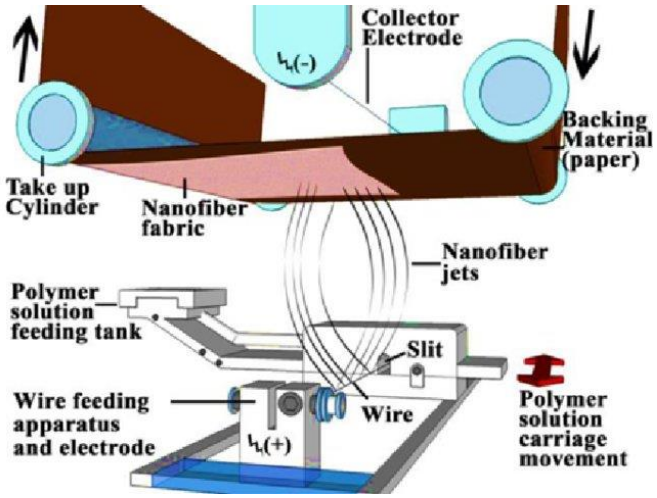




https://youtu.be/T8e5_6ullzQ

# Needle-less electrospinning - wire








https://youtu.be/oR_z54vV9Os

# Industrial line

# Conditions

- Critical value of electric field intensity

$$E_c = \sqrt[4]{\frac{4\gamma\rho g}{\varepsilon^2}}$$

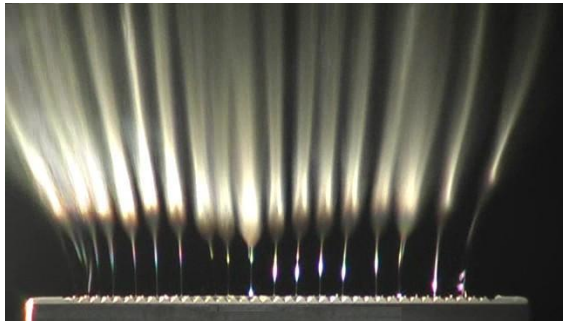
- Electrospinning number

$$\Gamma = \frac{a\varepsilon E_c^2}{2\gamma} \qquad \Gamma \geq 1$$

- Distance between adjacent fluid nozzles

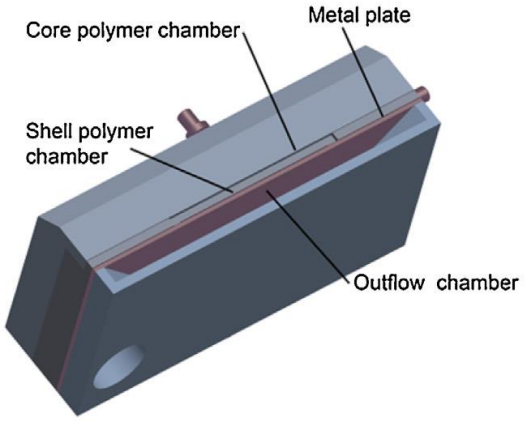
$$\Lambda = \frac{3\pi}{\Gamma + \sqrt{\Gamma^2 - 3/4}}$$

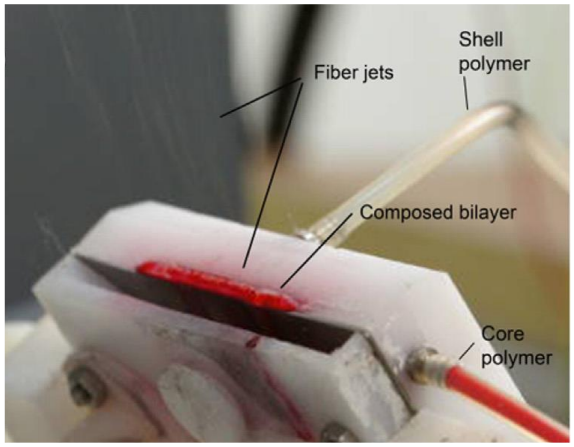
- Relaxation time

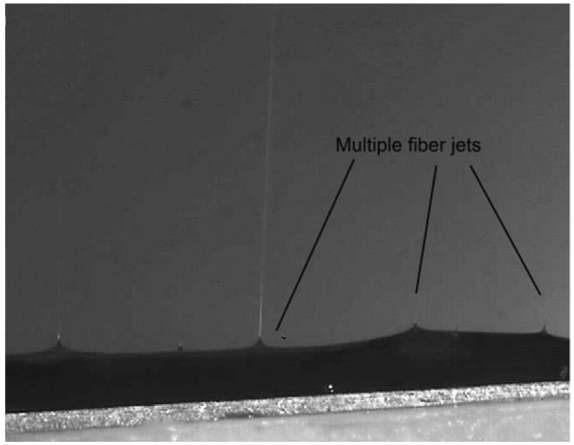


# Needle-less coaxial electrospinning

- Two layers of different liquids flow one after the other and spin at the same time.

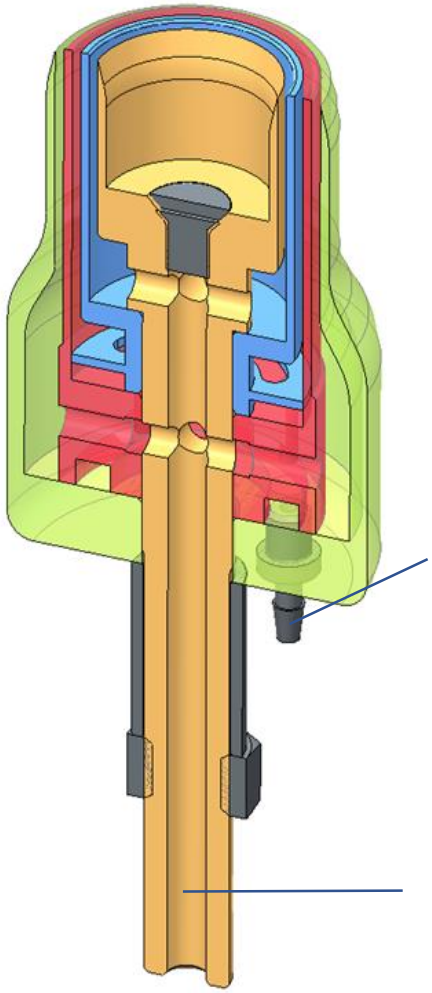



- Higher productivity compared to needle coaxial spinning

# Needle-less coaxial electrospinning



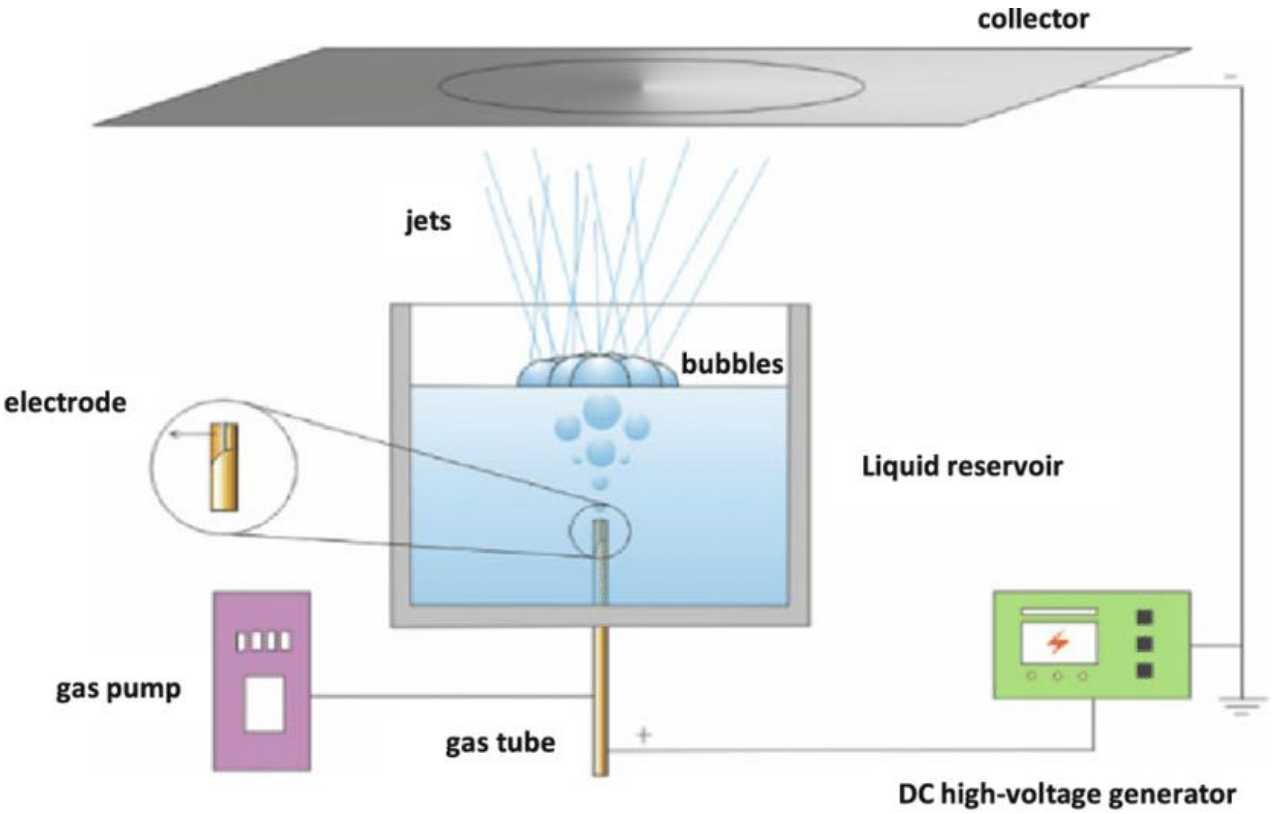
Inner material

Outer material

# Bubblespinning

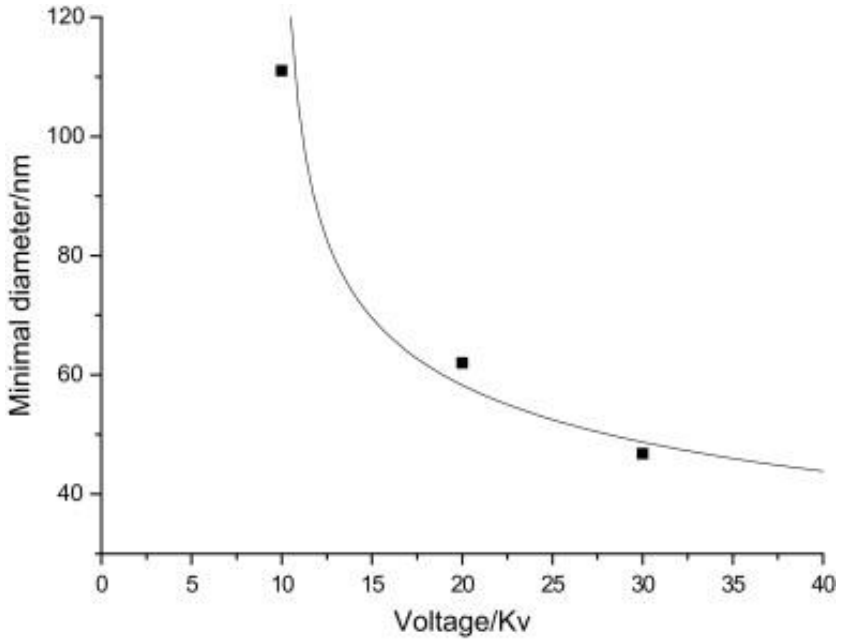
- It uses gas to create bubbles
  - Argon, helium, air
- Spinning from multiple bubbles
- It is difficult to influence the size and number of bubbles
- Production of finer fibers
- Spinning of higher concentrations of polymer solutions

# Bubblespinning

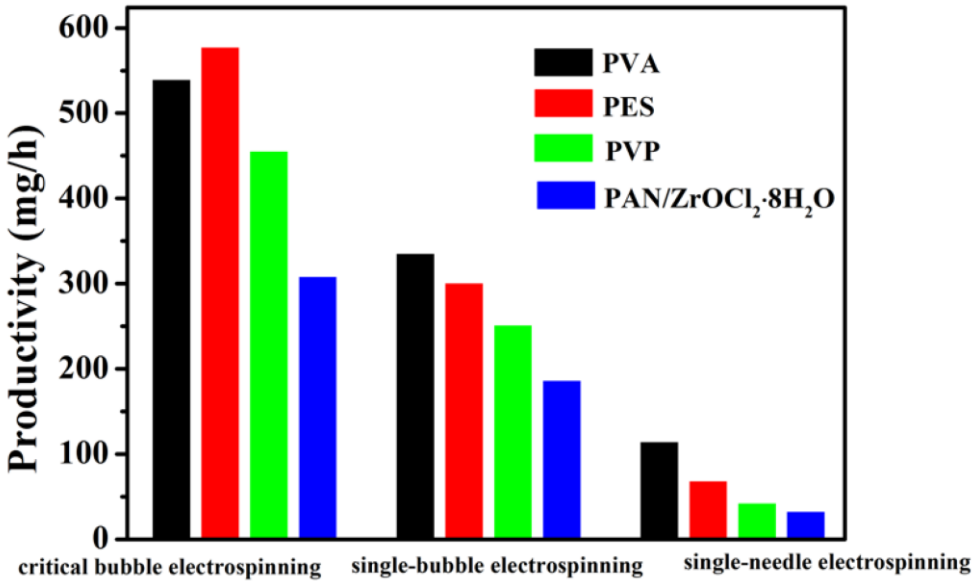



https://youtu.be/pahaDrccUEU

# Bubblespinning




Minimal diameter of nanofibers v.s. applied voltage.




The nanofiber productivity of single-needle/bubble electrospinning and critical bubble electrospinning.

# Summary

Electrostatic spinning

- Needle
- Needle-less

Modification of electrostatic spinning

- Coaxial spinning
- Electroblowing
- Bubblespinning

# Thank you for your attention!

# TEST

- What are the methods of electrostatic spinning?
- What affects the critical voltage in needle spinning?
- What electrodes do we use for needle-less spinning?
- What materials can be formed by coaxial spinning?