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 1

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Funded by the European Union
NextGenerationEU

CZECH RECOVERY PLAN

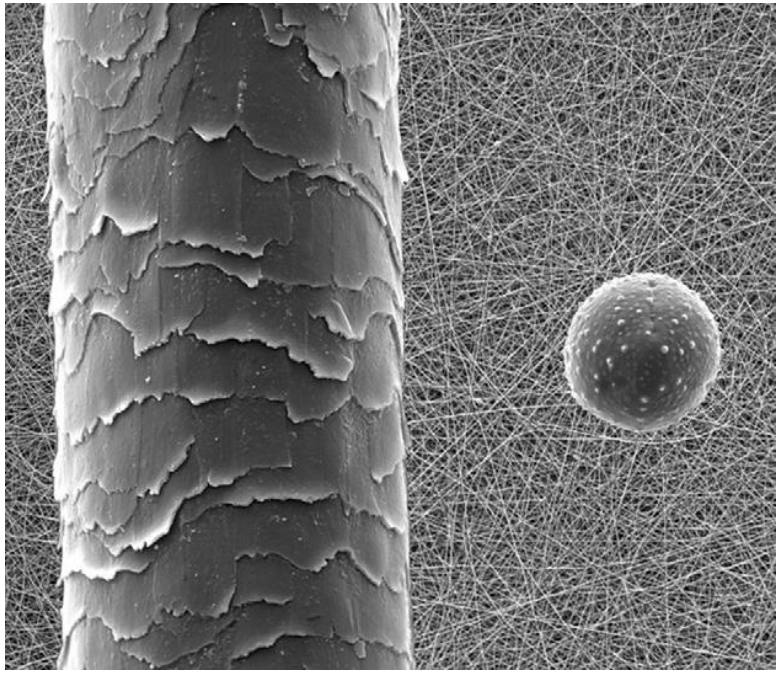
MINISTRY OF EDUCATION, YOUTH AND SPORTS

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

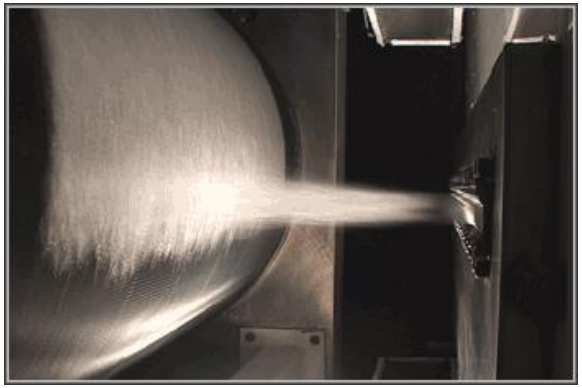
Repetition

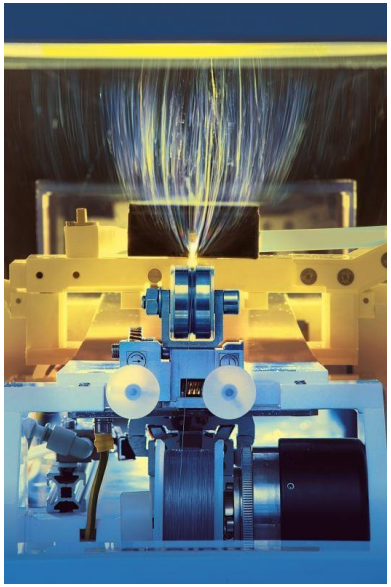
- From natural materials
  - Proteins: collagen, gelatin, elastin
  - Polysaccharides: hyaluronic acid, cellulose, chitosan,…
- From synthetic materials
  - Polyamides, polyesters, polyurethanes, polyvinyls,…
- From homopolymers, copolymers
- From blends
- From solutions or melts

Repetition

- Electrostatic spinning
- Meltblown
- Centrifugal spinning
- Bicomponent fibers

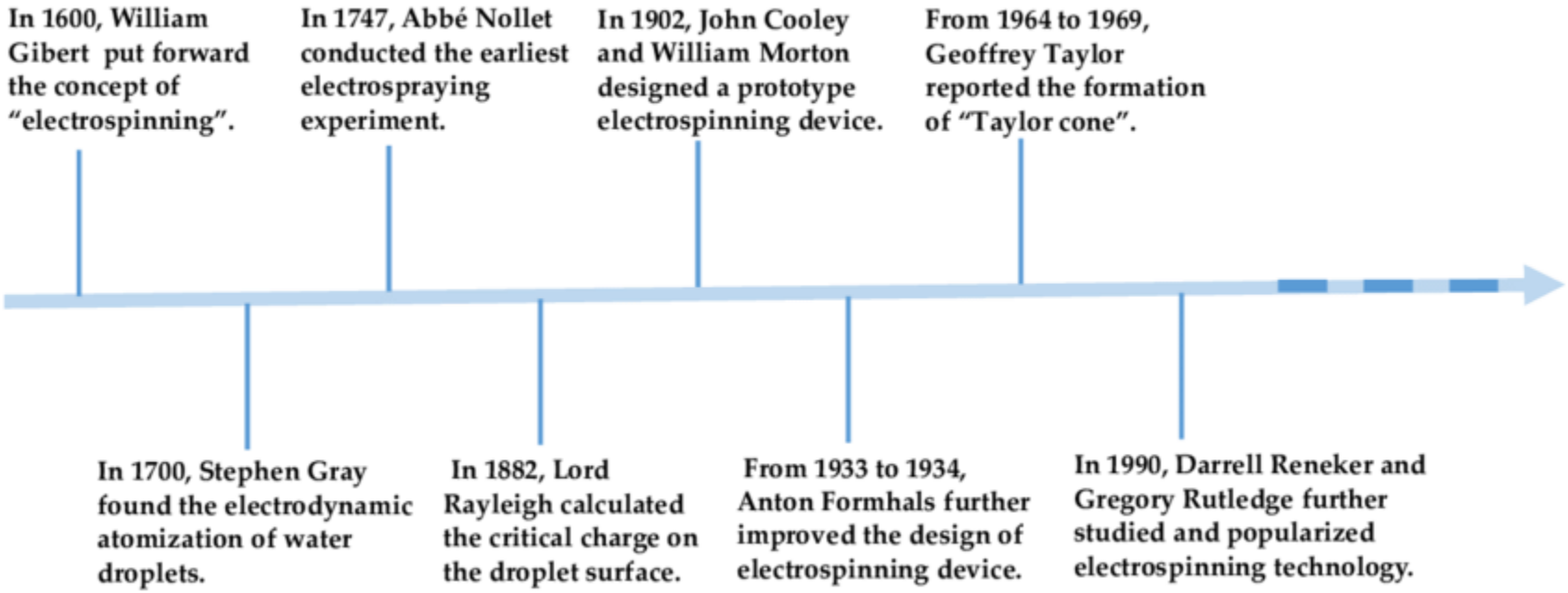
- Drawing
- Synthesis template
- Phase separation
- Self-assembly
- Freezing





Electrospinning

History of electrospinning



No. 705,691. Patented July 29, 1902.

W. J. MORTON.

METHOD OF DISPERSING FLUIDS.

(Application filed Feb. 20, 1900.)

(No Model.)

Fig. 1

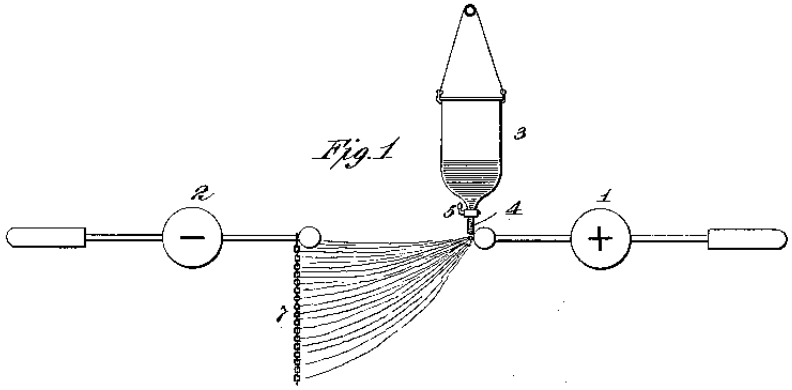


Fig. 2

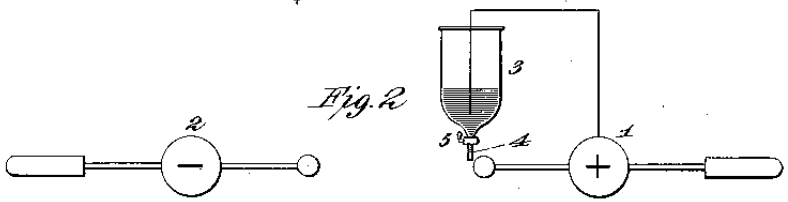


Fig. 3

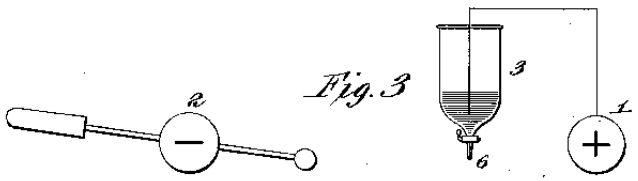
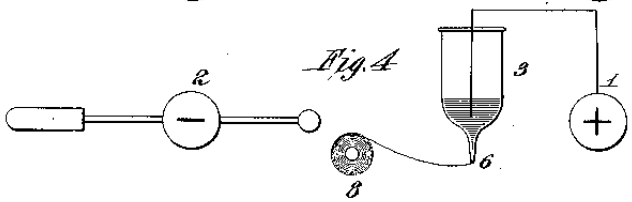


Fig. 4



Witnesses:

Jas. F. Coleman

Jno. A. Taylor

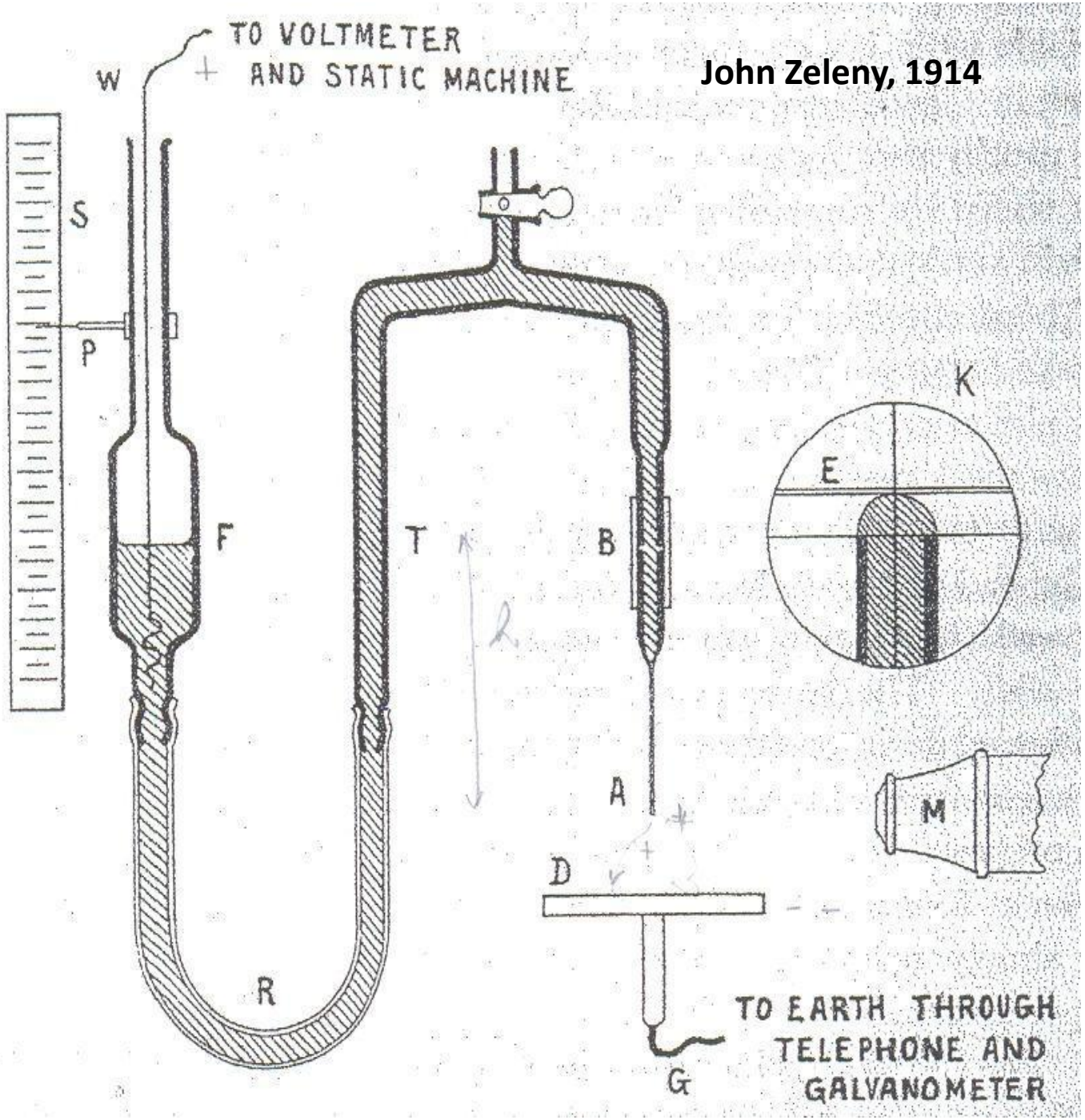
Inventor

William James Morton

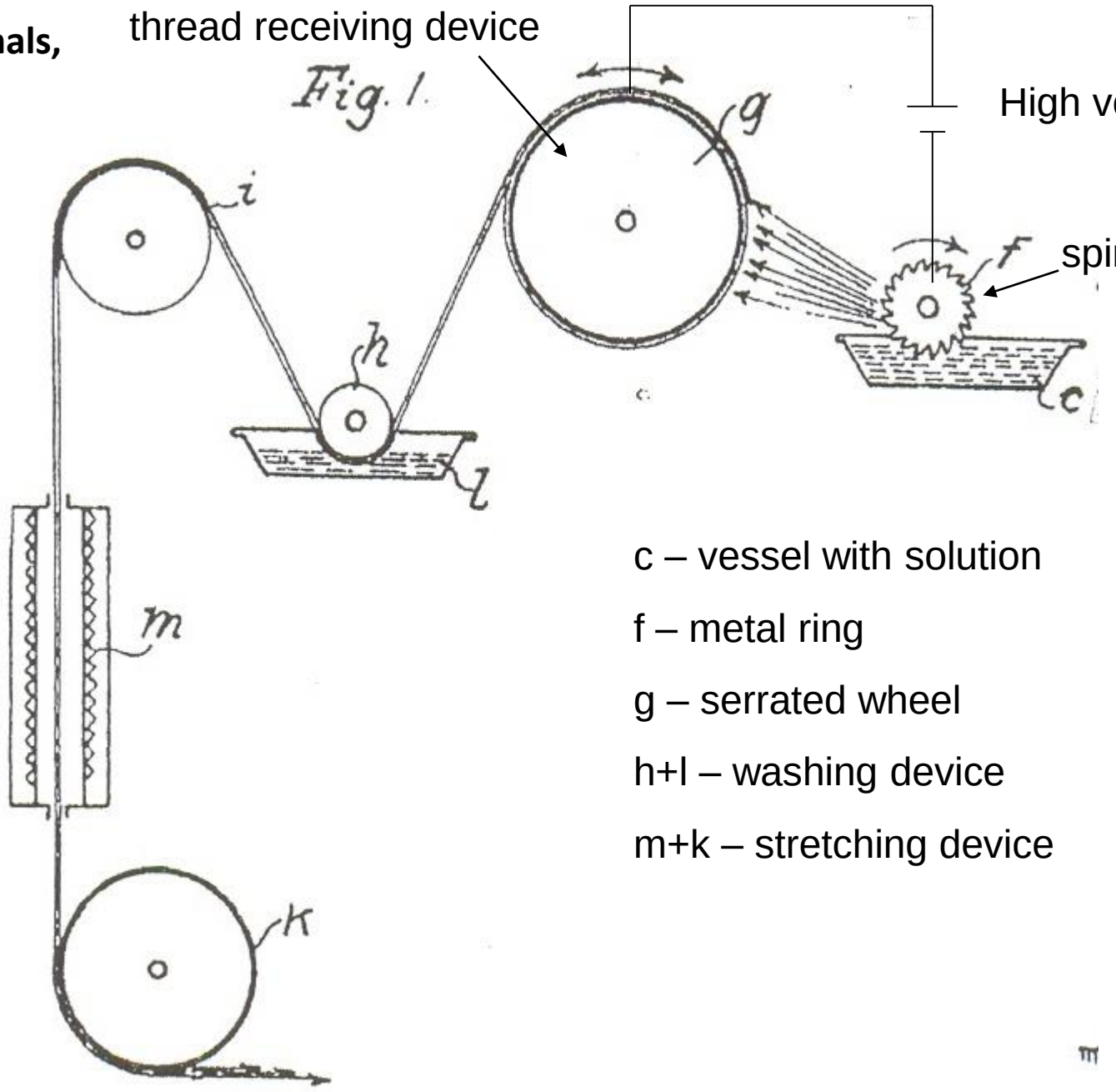
by Byrn Edmonds & Byrn

Attys.

John Zeleny, 1914



Anton Formhals, 1932



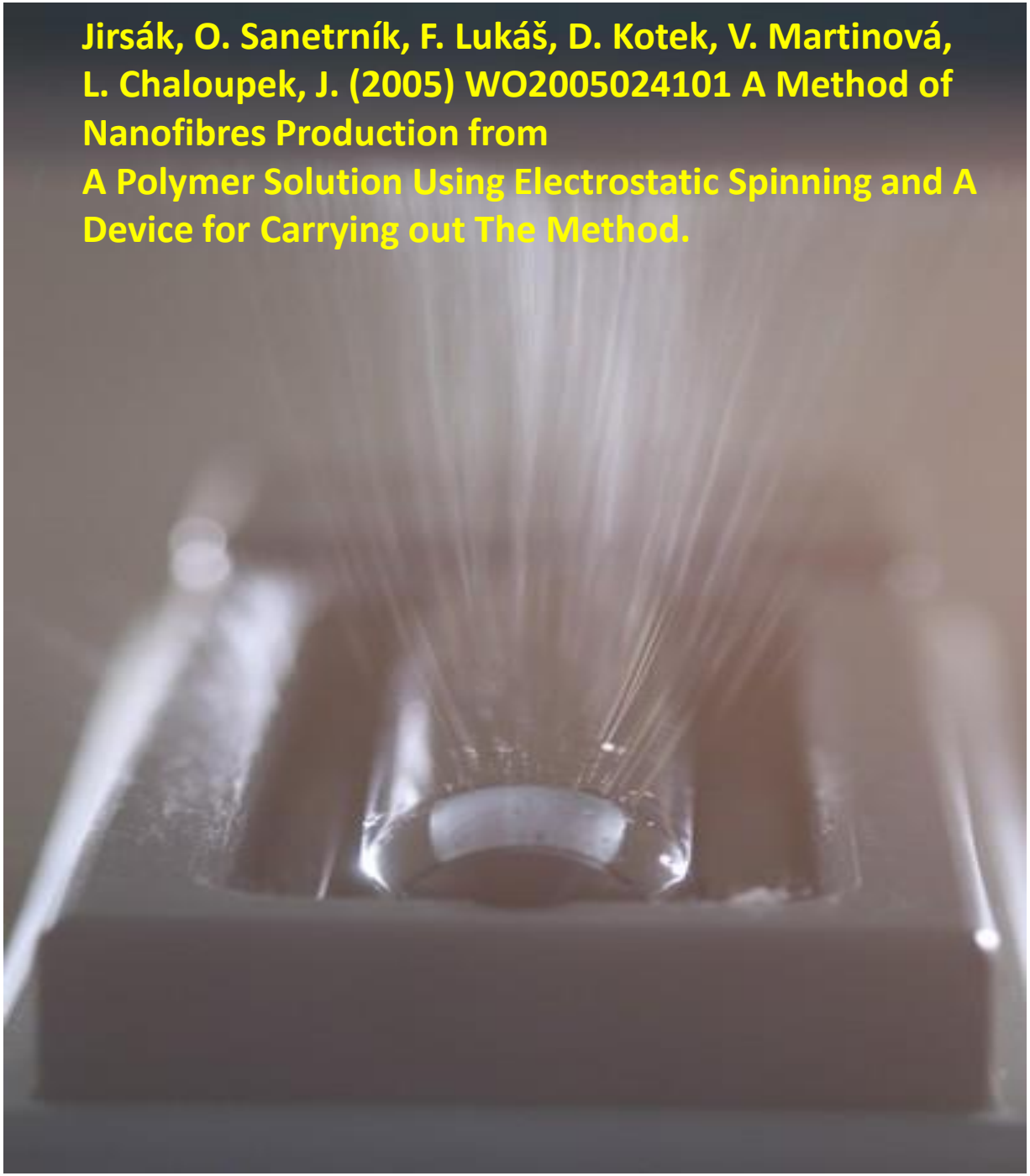
c – vessel with solution

f – metal ring

g – serrated wheel

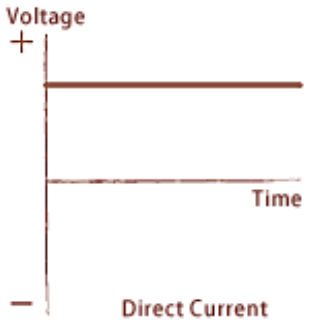
h+l – washing device

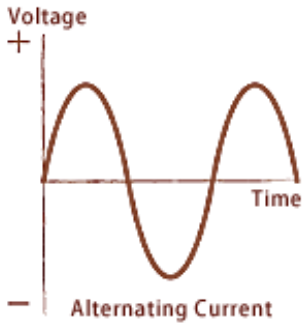
m+k – stretching device


Jirsák, O. Sanetrník, F. Lukáš, D. Kotek, V. Martinová, L. Chaloupek, J. (2005) WO2005024101 A Method of Nanofibres Production from
A Polymer Solution Using Electrostatic Spinning and A Device for Carrying out The Method.

Electrospinning

- 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



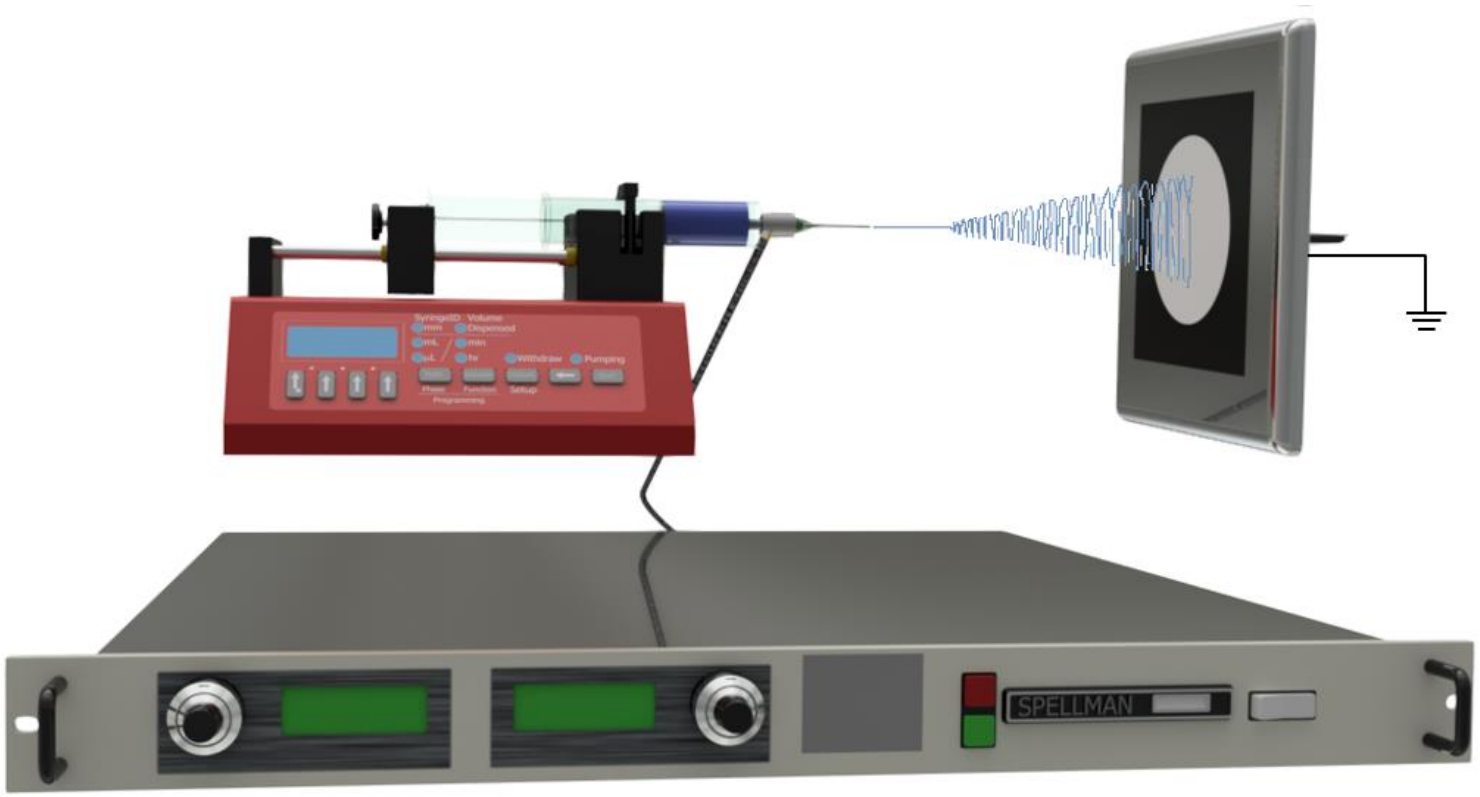


Types of electrospinning

Needle electrospinning

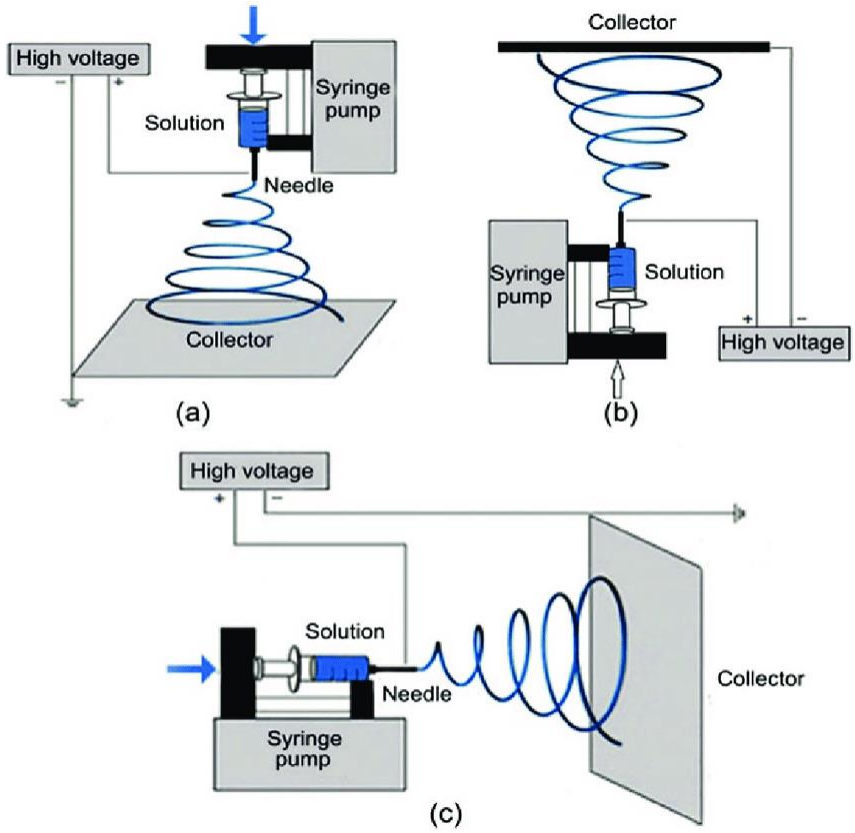
Needle-less electrospinning

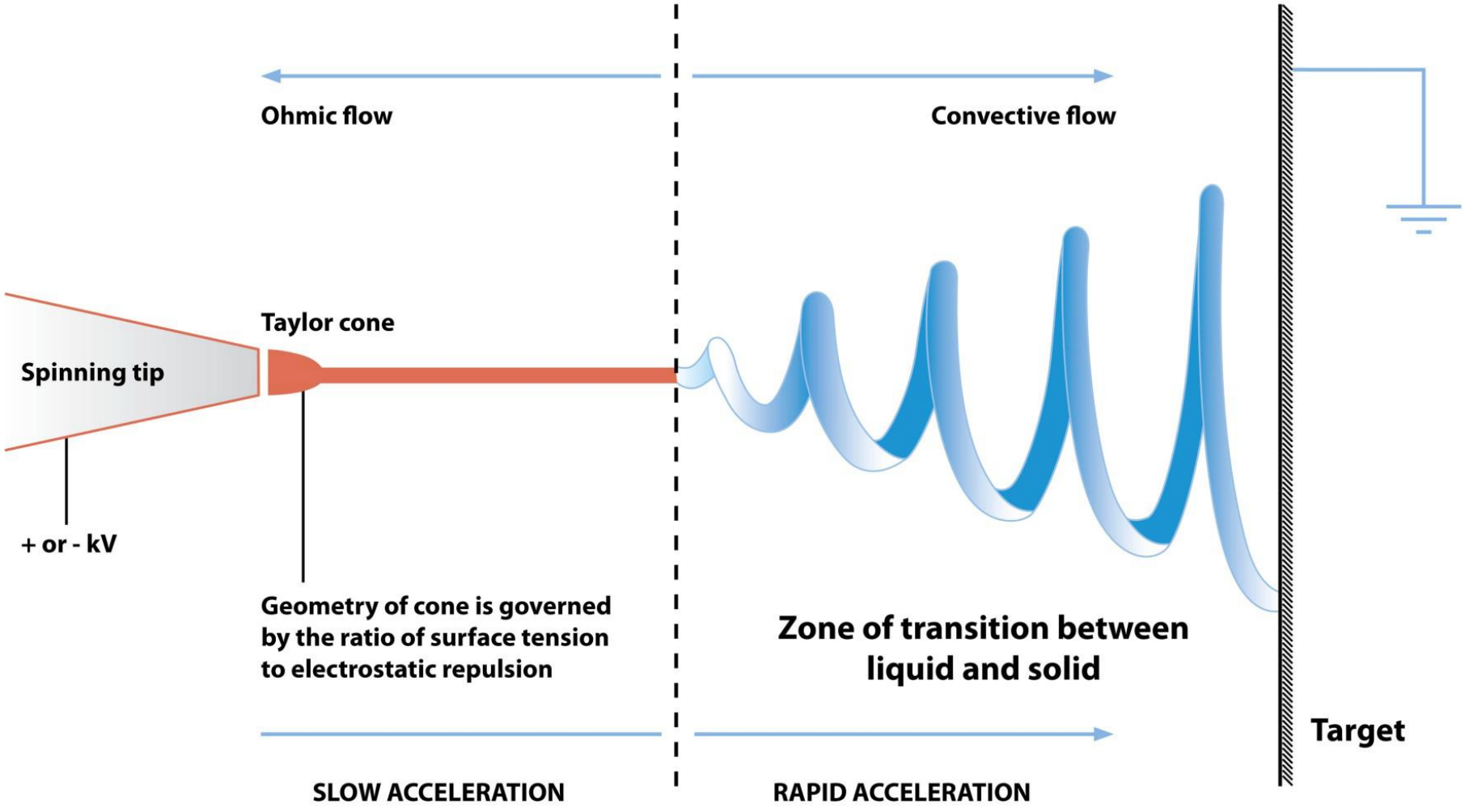
Needle electrospinning



Needle electrospinning

- Any configuration
- Electrode
  - Charged - positive / negative
  - Grounded
- Collector
  - Charged - positive / negative
  - Grounded

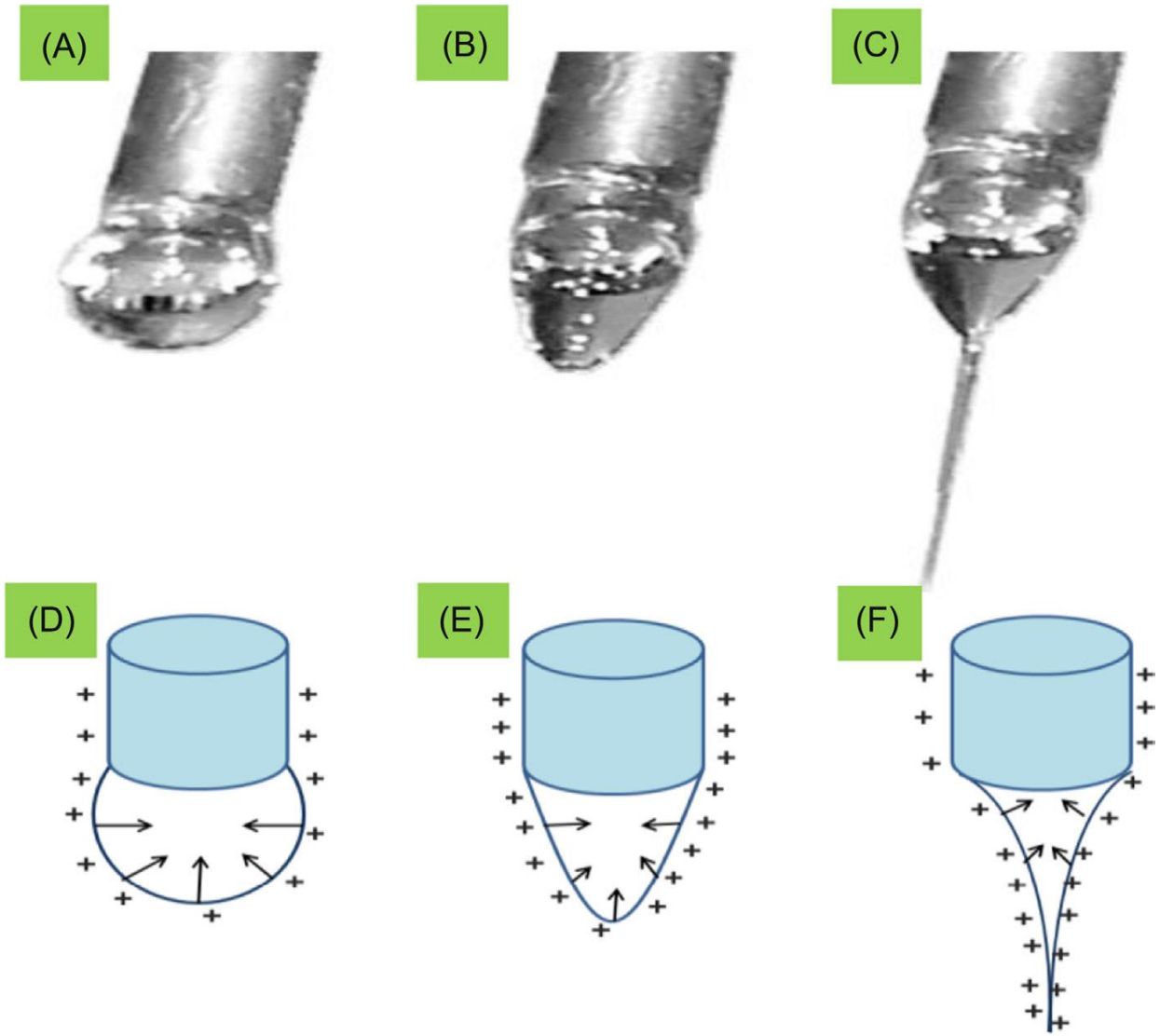


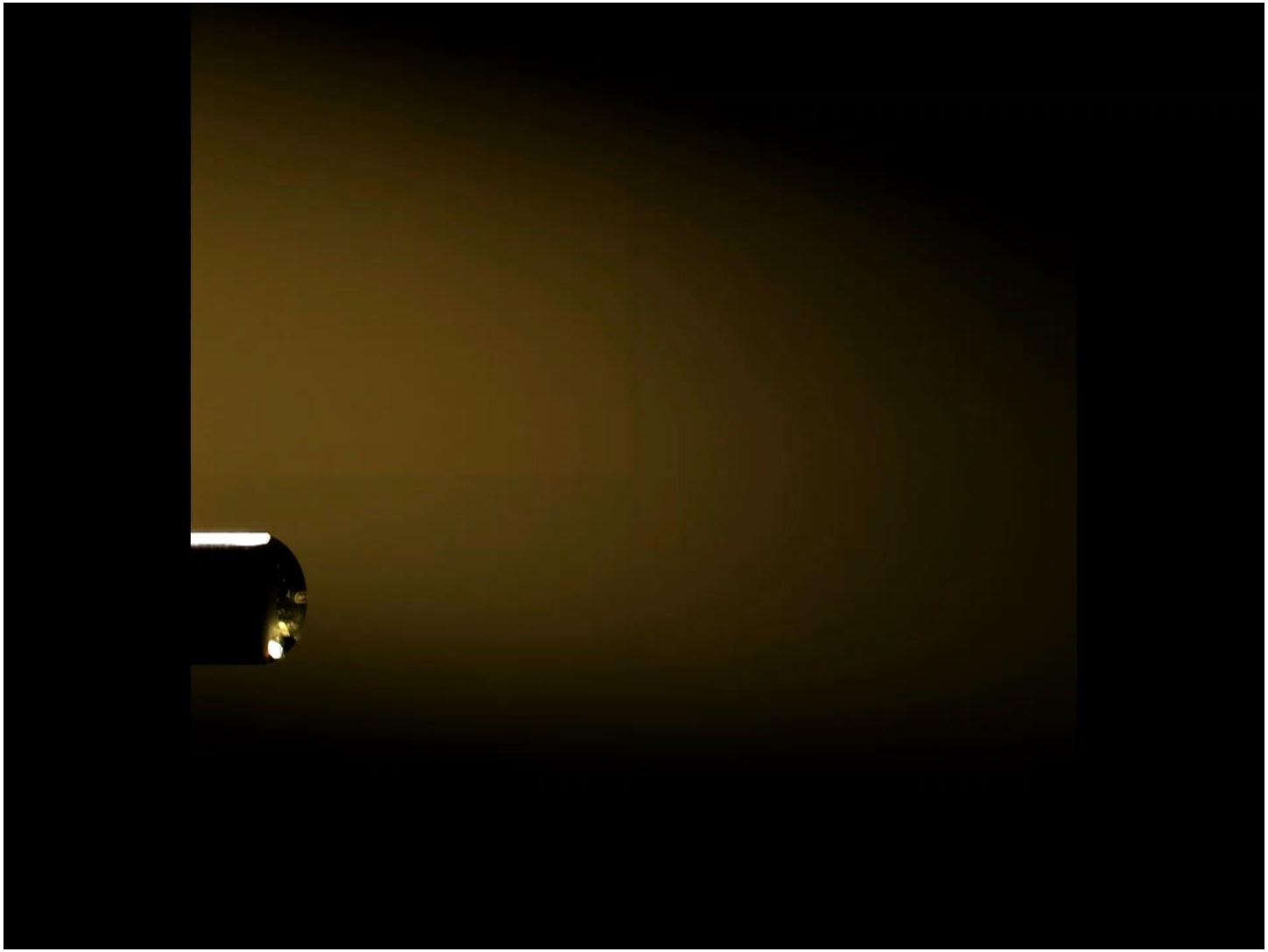


Capillary force $F_c = 2\pi r\gamma cos\theta$

Electric force $F_e = \int (1/2\varepsilon E^2) ds$

$F_c = F_e$


(A)
(B)
(C)
(D)
(E)
(F)



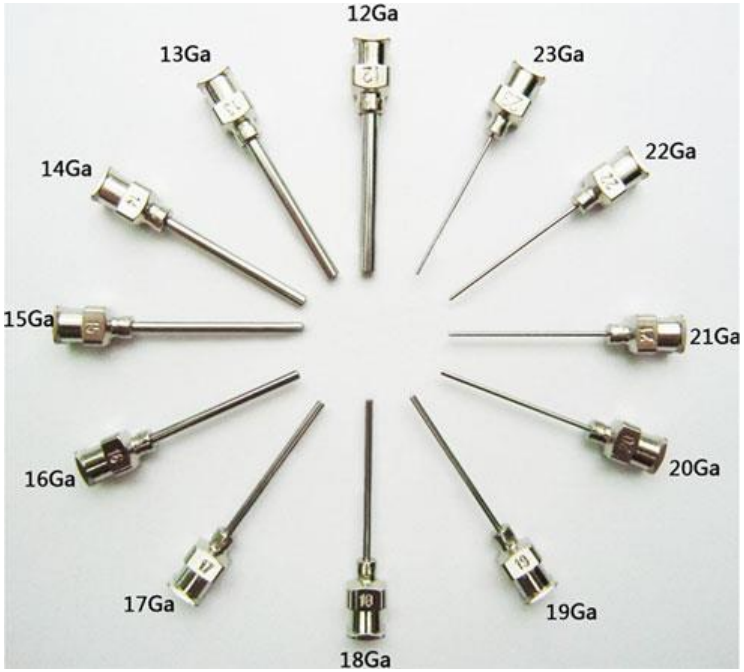
Critical voltage

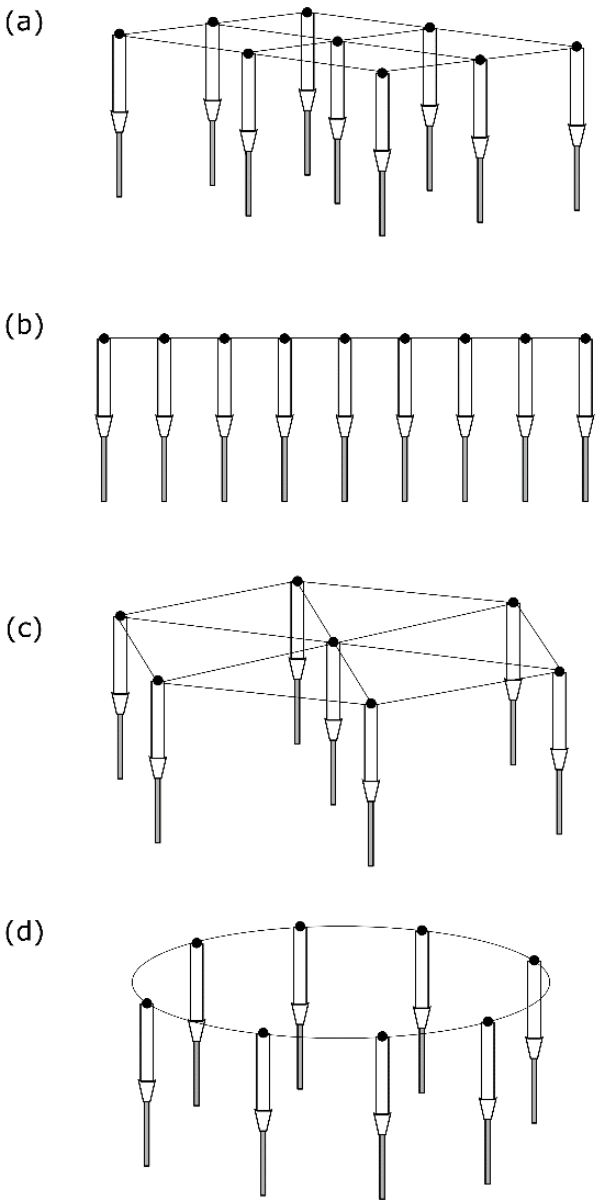
- Voltage at which electrostatic spinning occurs

- Affected by:
  - The diameter of the needle
  - Distance of the electrode from the collector
  - Surface tension

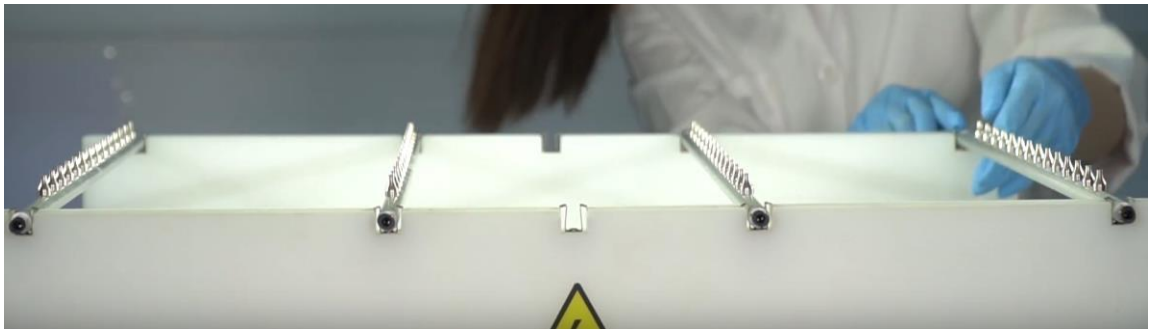
$$V_c^2 = 4\ln\left(\frac{2h}{R}\right)(1{,}3\pi\gamma R)(0{,}09)$$

Needle electrospinning





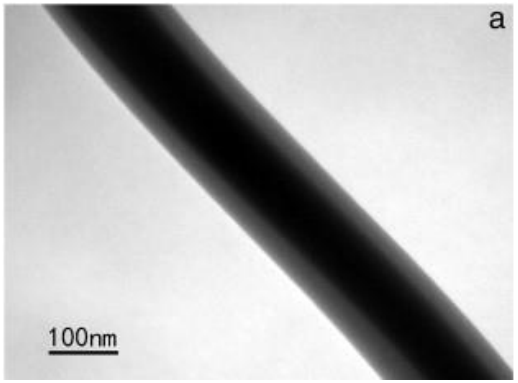
Industrial line

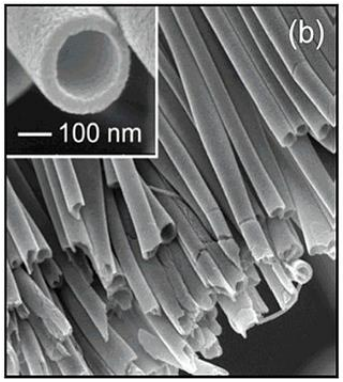


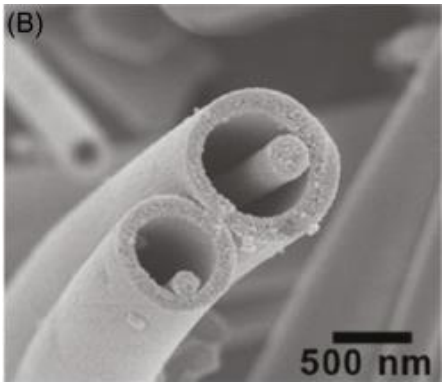
Coaxial electrospinning

- Creation of bicomponent fibers - core / sheath
- Possibility of creating hollow fibers
- Drug encapsulation

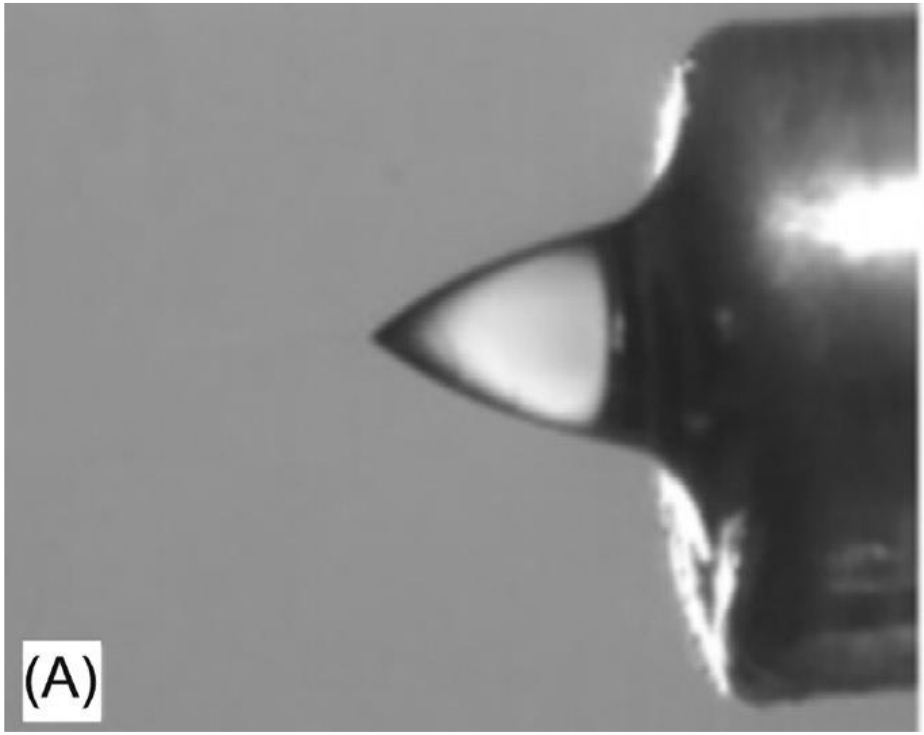
- Electrospun materials must not collide with each other

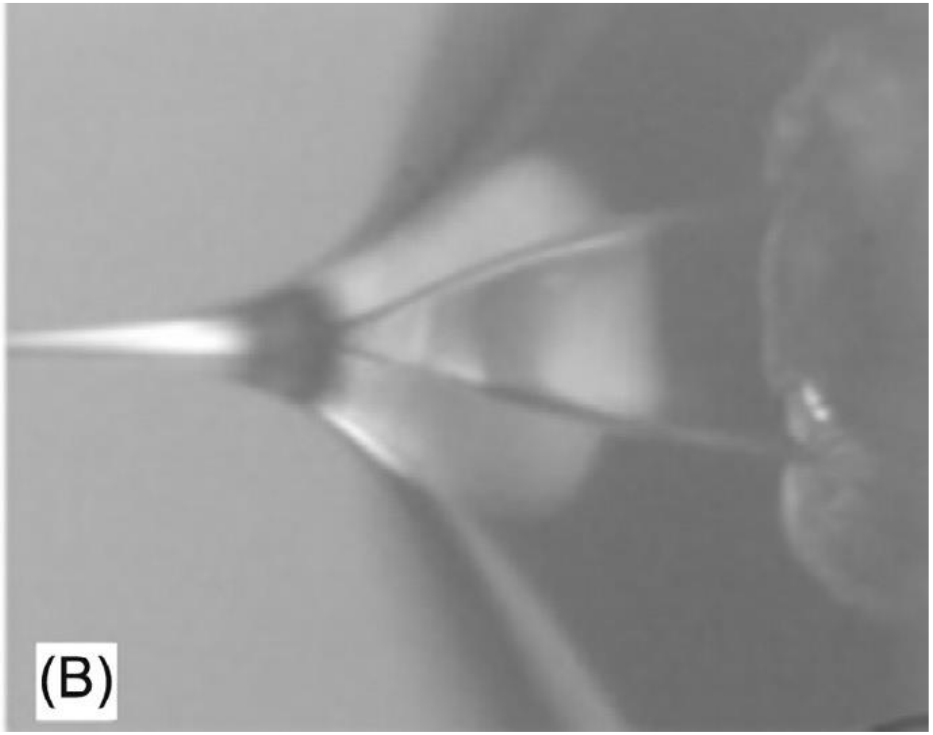




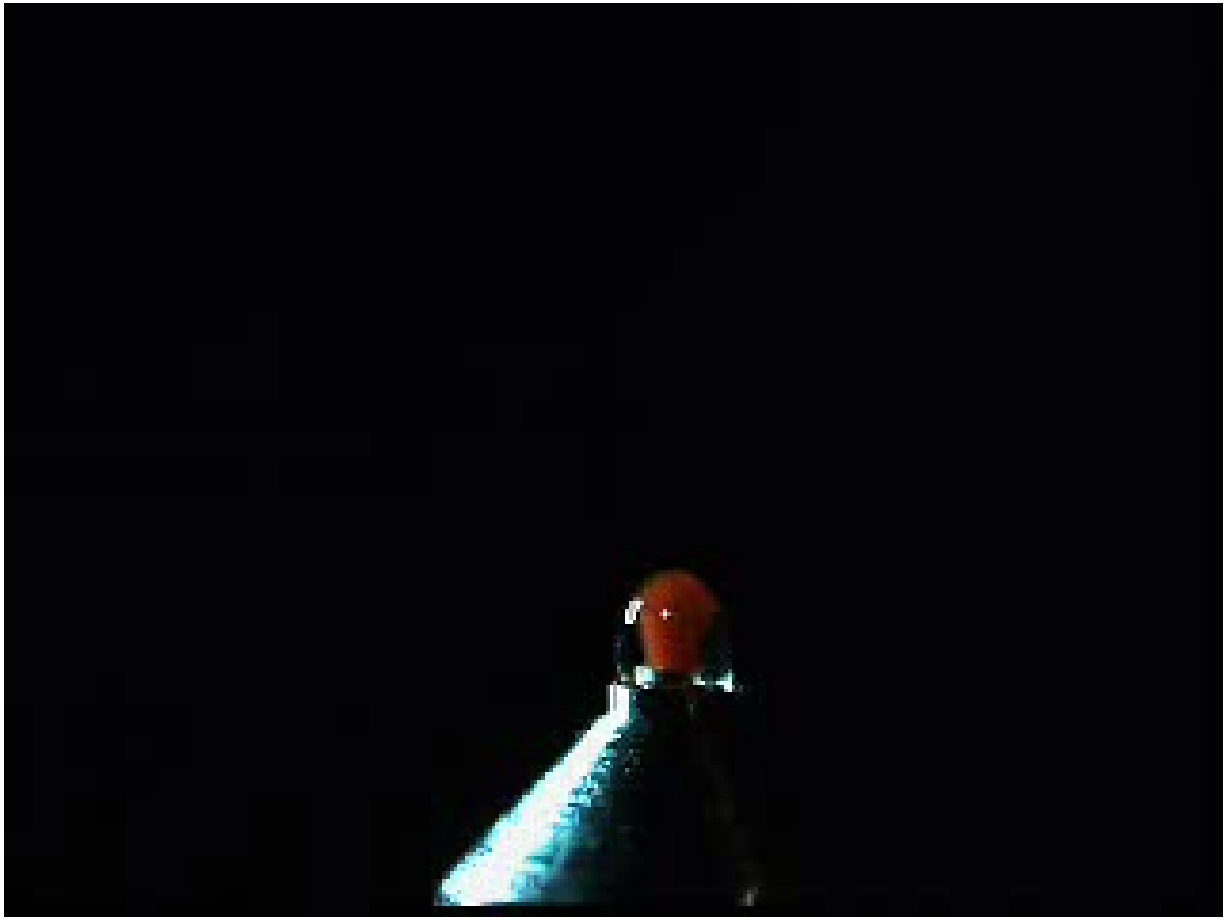


Coaxial electrospinning

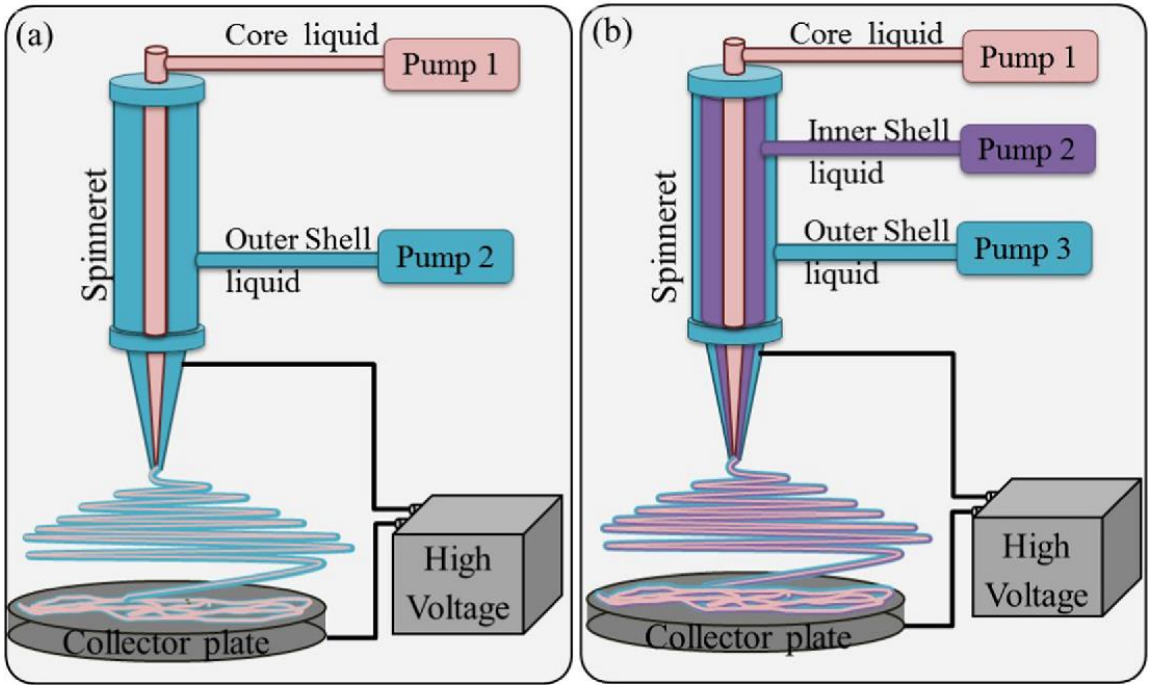




Coaxial electrospinning

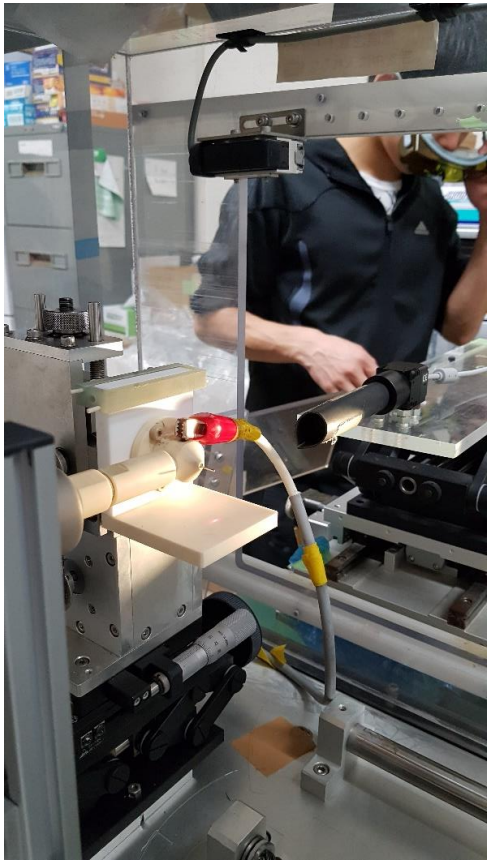


Needle coaxial electrospinning

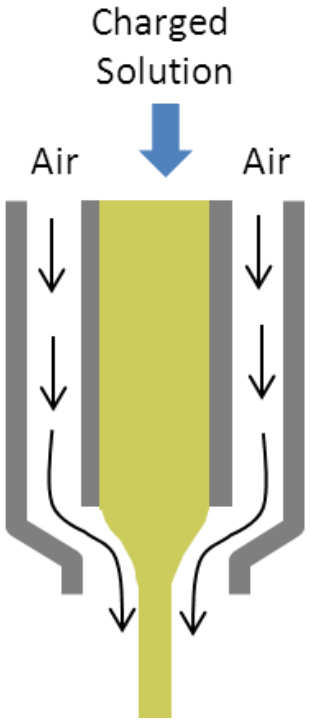


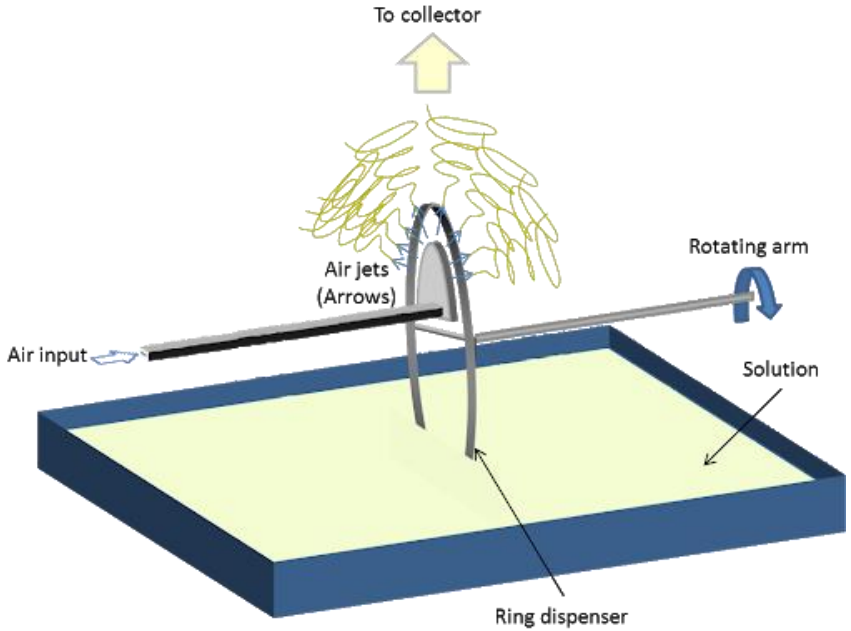
Electroblowing

- It uses a compressed air stream
- Possibility to use hot air
- Facilitate nozzle creation
- Increase productivity
- Routing of deposited fibers
- For melts - cooling, drawing of fibers

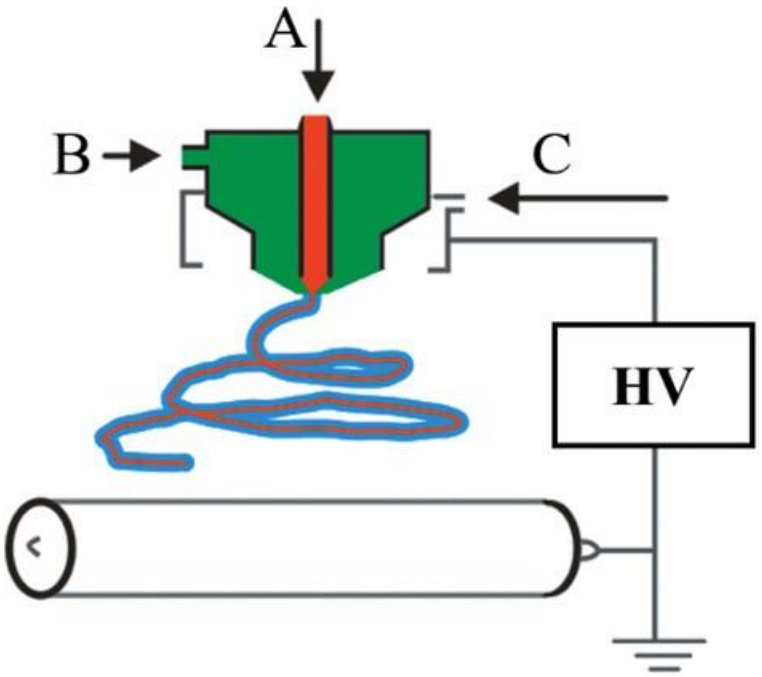


Electroblowing - types





Coaxial electroblowing



Thank you for your attention!

TEST

- What are the methods of electrostatic spinning?
- What affects the critical voltage in needle spinning?
- What materials can be formed by coaxial spinning?