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_Other methods of nanofiber production

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NextGenerationEU

CZECH RECOVERY PLAN

MINISTRY OF EDUCATION, YOUTH AND SPORTS

Repetition

Production of nanofibers:

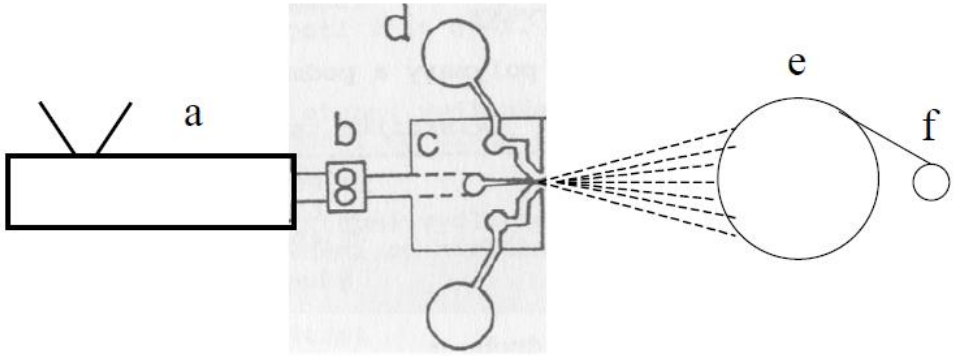
- DC spinning
- AC spinning
- Centrifugal spinning

Other methods of production

- Melt-blown
- Bicomponent fibers
- Drawing
- Synthesis by template
- Phase separation
- Self-assembly

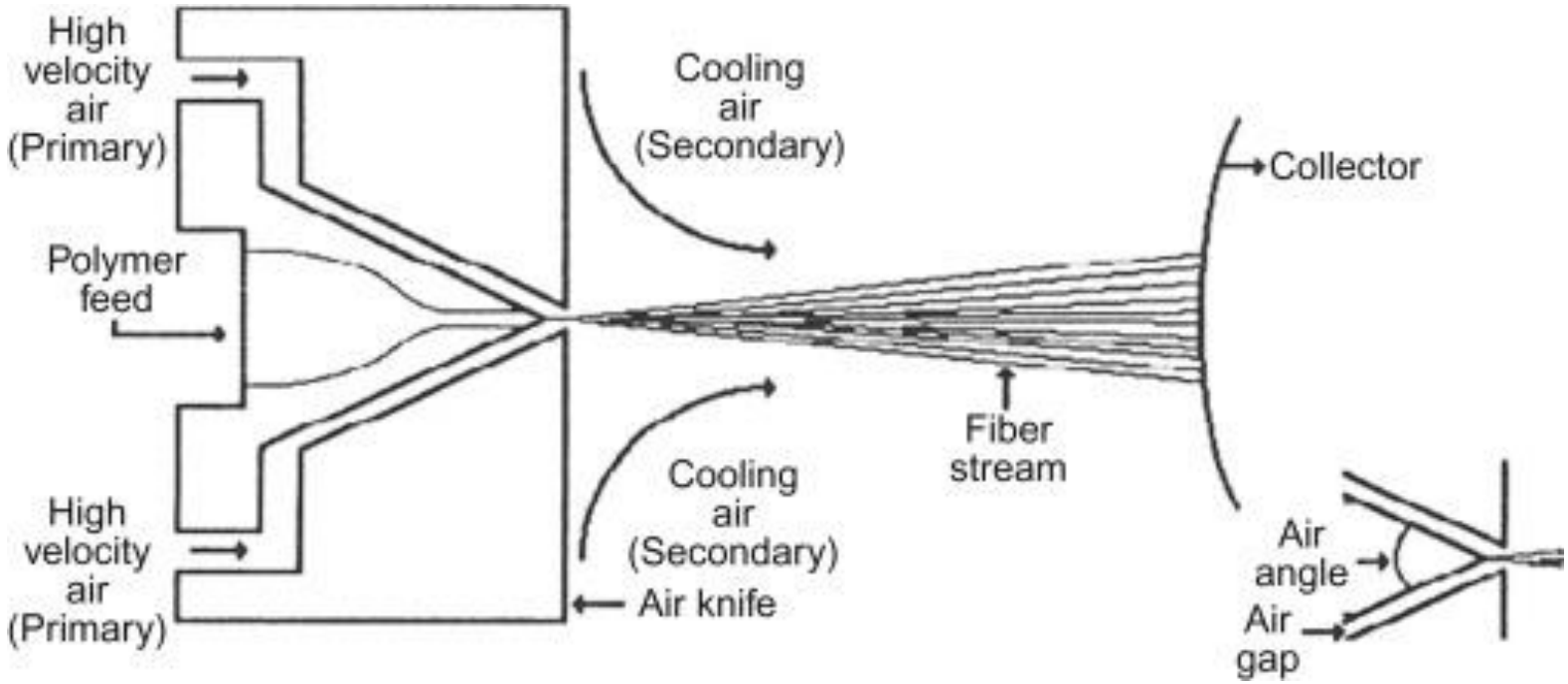
Melt-blown

- Production of fibers by blowing polymer melt



- Process:
  - Polymer melting
  - Transport of melt to the nozzle
  - Entrainment of the melt by a stream of hot air
  - Fiber drawing
  - Storing fibers on the collector

Melt-blown


High velocity air (Primary)
Polymer feed
High velocity air (Primary)
Cooling air (Secondary)
Cooling air (Secondary)
Air knife
Fiber stream
Collector
Air angle
Air gap

Melt-blown

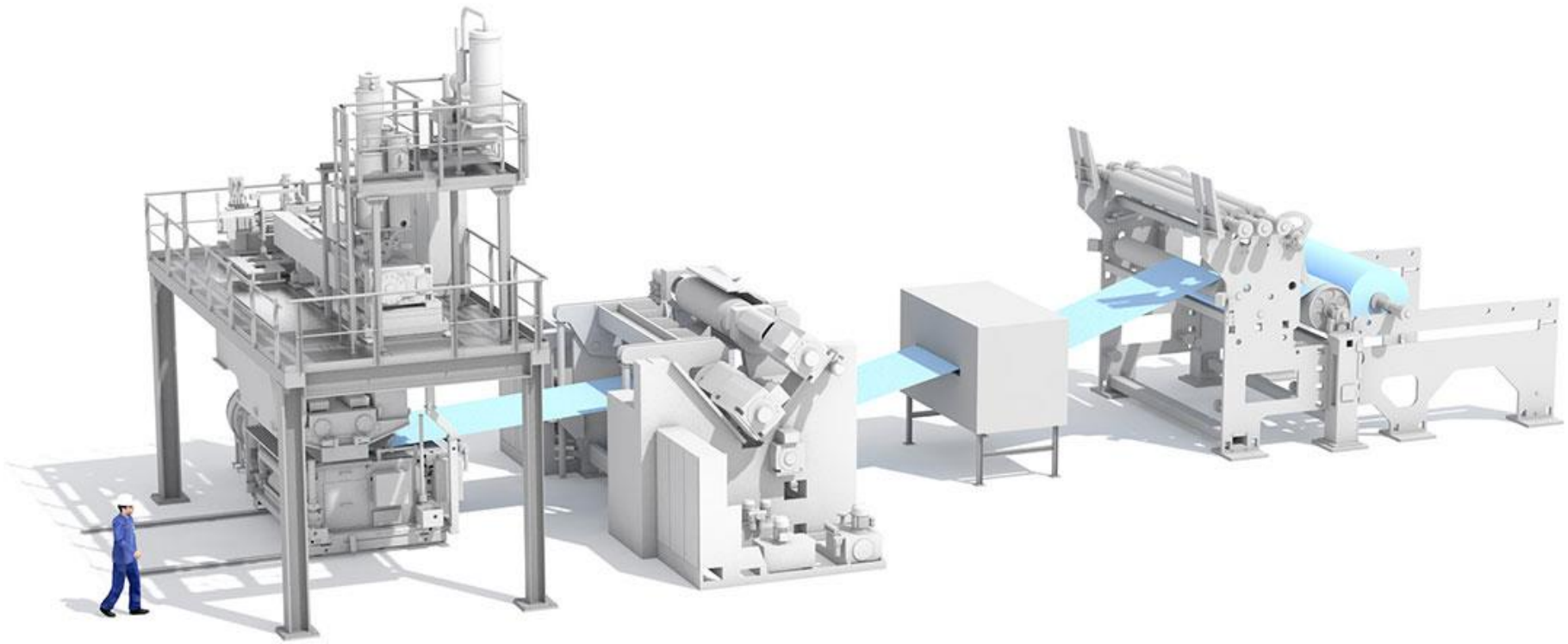
- Process parameters:
  - Melt flow index
    - MFI: 1000-1800
  - Hole size
    - 0.1-0.15 mm
  - Number of holes
    - 100 holes per inch
  - Dosage
    - 0.01 g/hole/min
  - Air temperature
    - 290-400 °C
  - Air flow rate
    - 100-500 mps

Melt-blown

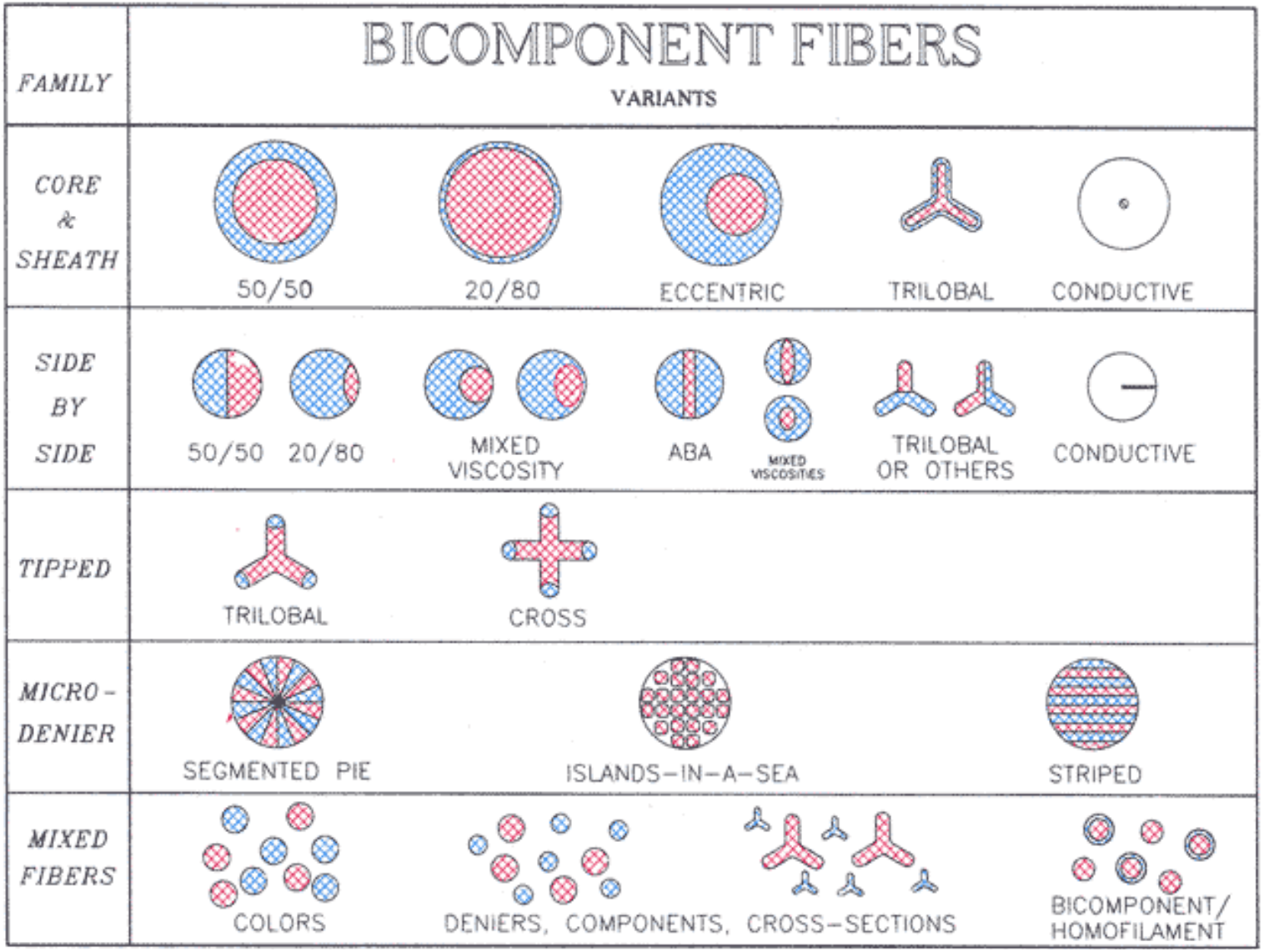
Run I.D.	T_p, T_a (°C)	η^* at 1 s^{-1} (Pa s)	m_p (g/min)	ϕ_a (SCFM)	Γ	d_{av} (μm)
PS-1	180	23	0.053	8	9	1.61
PS-2	260	1.6	0.07	7.5	6.4	0.62
PS-3	280	1.1	0.07	8	6.8	0.38
PP-1	180	35	0.35	6	0.5	1.23
PP-2	180	35	0.035	8	13.6	0.45
PP-3	220	15	0.035	8	13.6	0.30
PBT-1	265	137	0.35	4.5	0.4	1.22
PBT-2	265	137	0.035	10	17	0.44

Summary of the melt blowing experiments

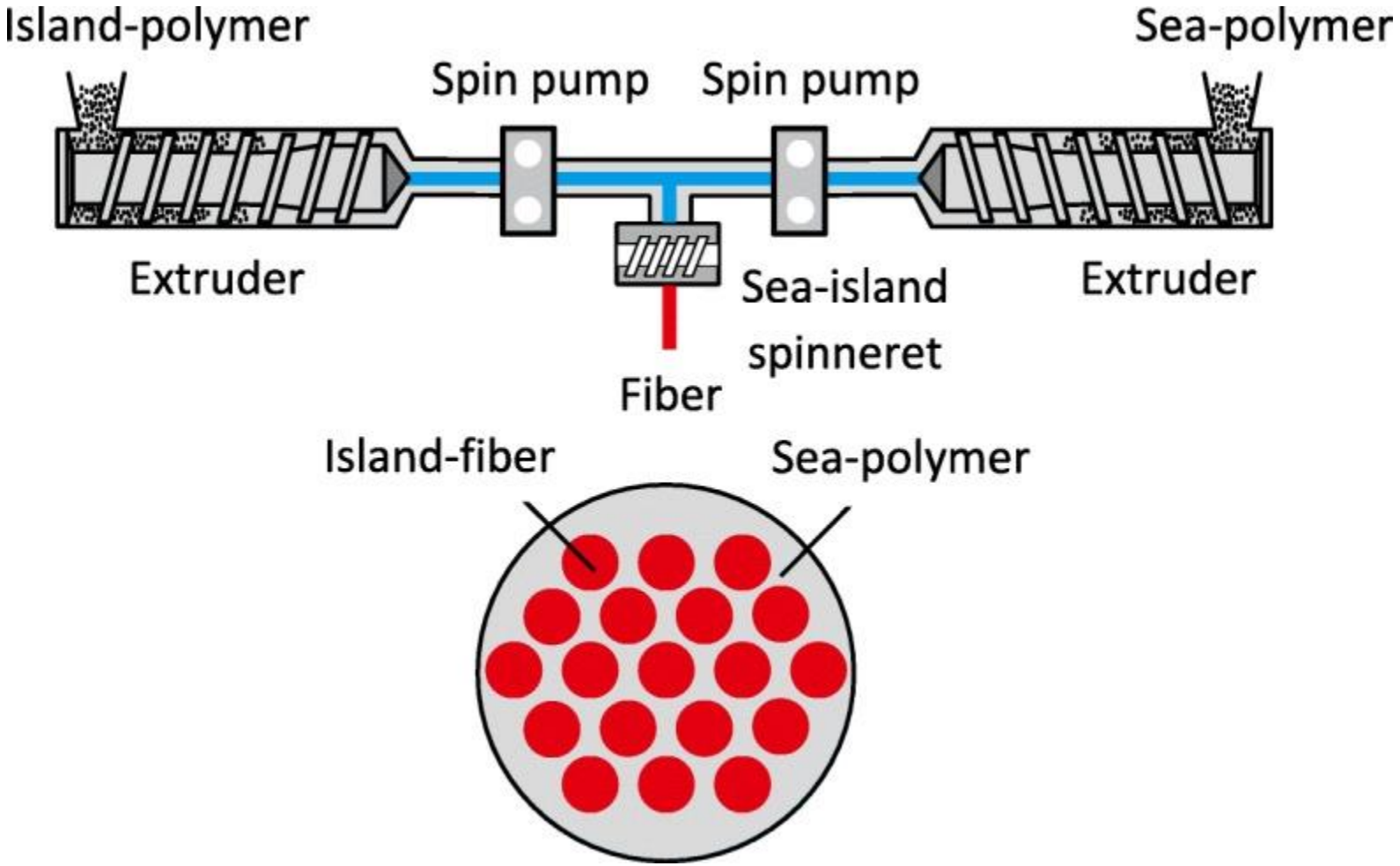
Melt-blown – industrial line



Bicomponent fibers

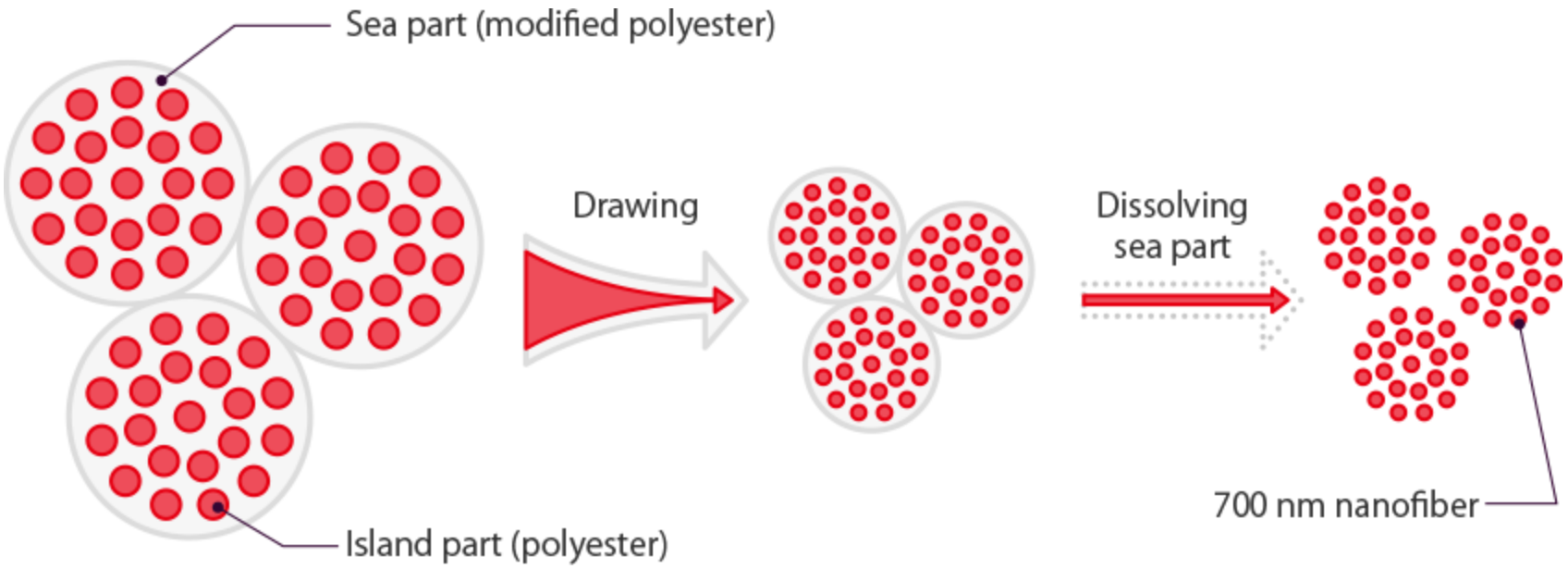


Bicomponent fibers



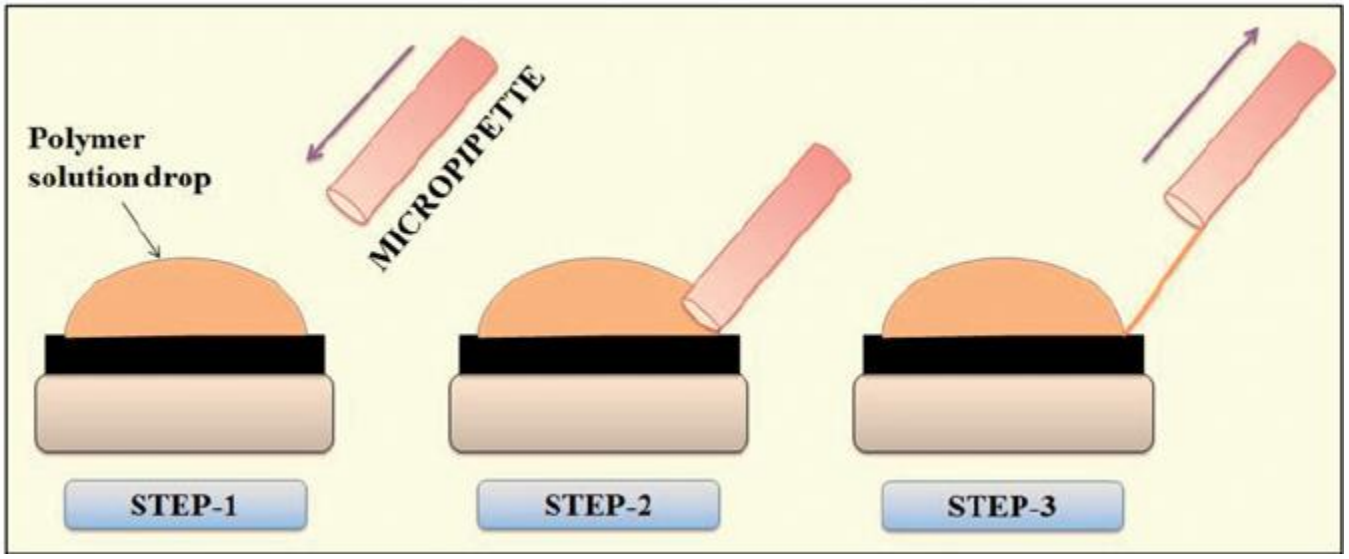
Bicomponent fibers

- Bicomponent fibers - type islands in the sea
- 240 - 1120 nanofibers from one bicomponent fiber

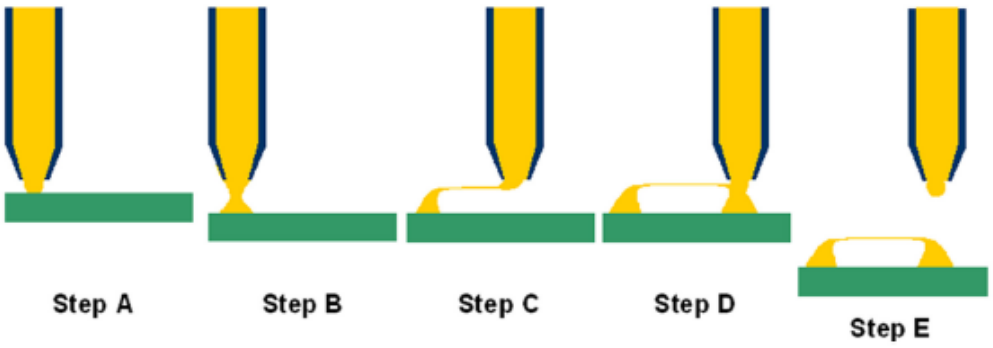


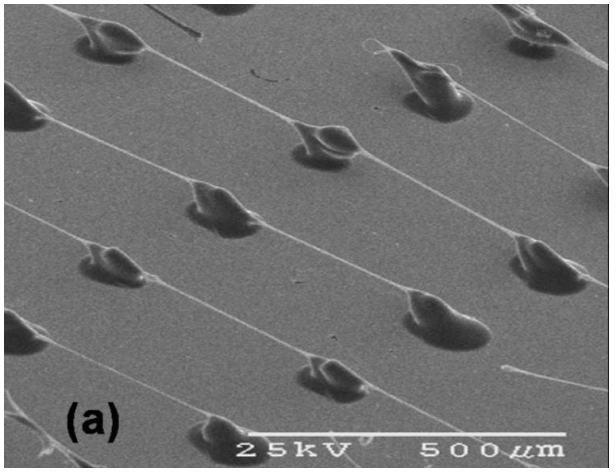
Drawing

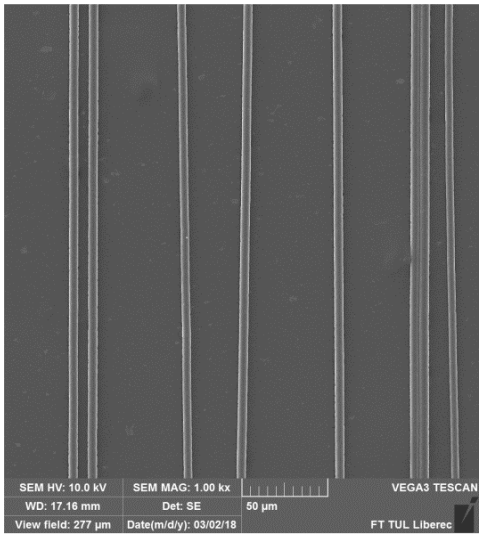
- Extraction of nanofiber from a polymer drop
- For solutions and melts
- Production of individual oriented fibers
- Unable to control fiber dimensions

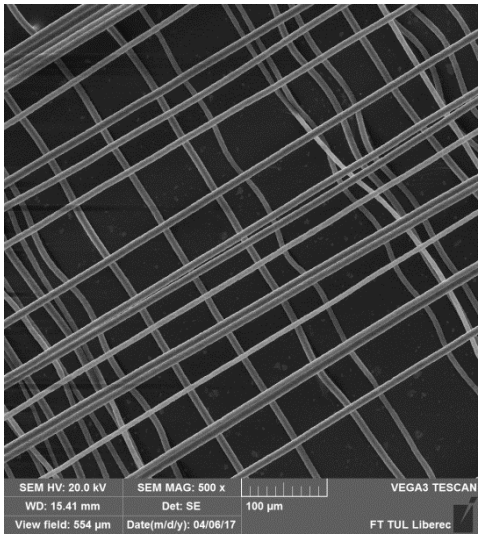


Drawing


Step A
Step B
Step C
Step D
Step E

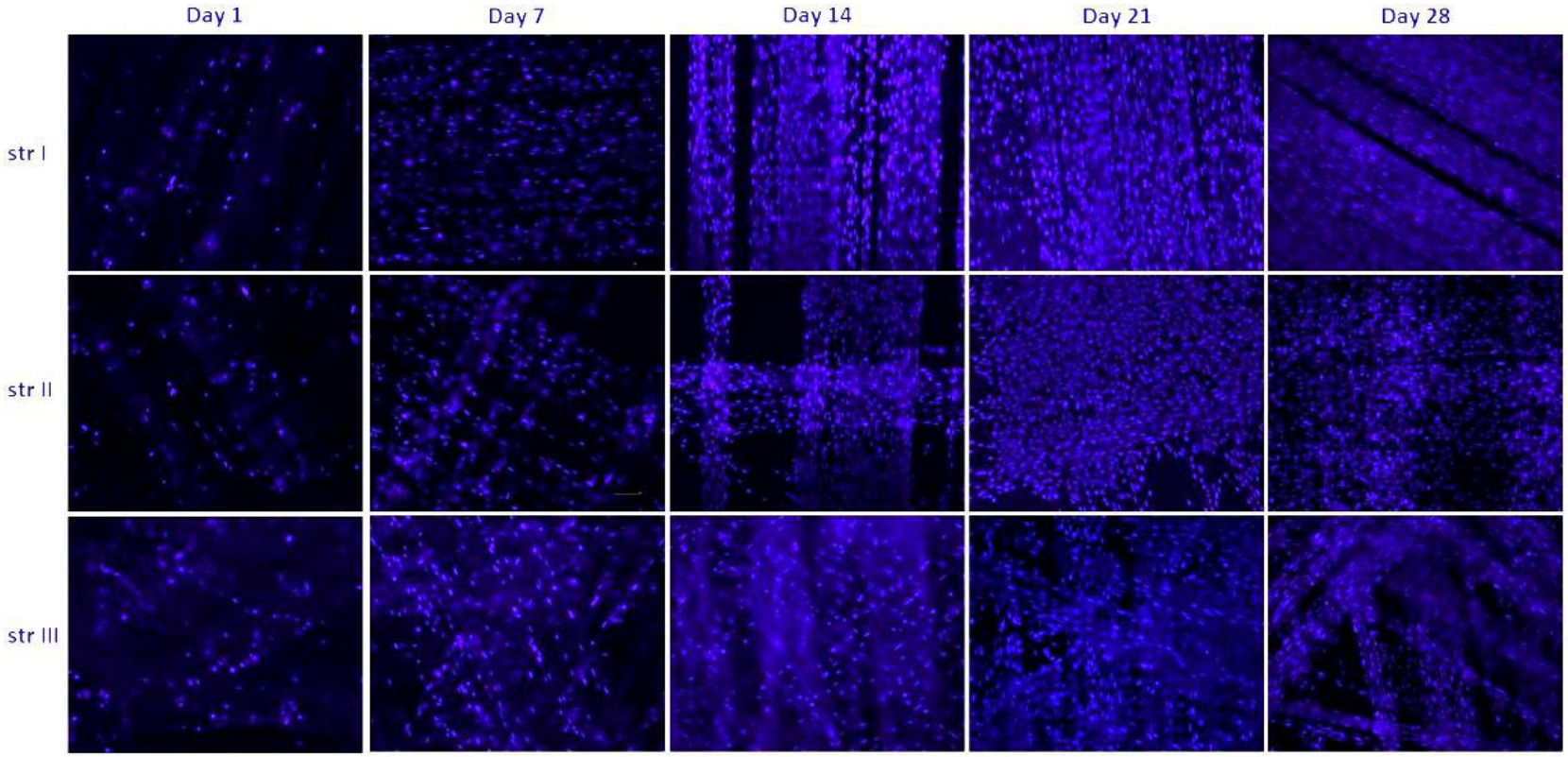

(a)
25kV 500μm


SEM HV: 10.0 kV
SEM MAG: 1.00 kx
VEGA3 TESCAN
WD: 17.16 mm
Det: SE
50 μm
View field: 277 μm
Date(m/d/y): 03/02/18
FT TUL Liberec


SEM HV: 20.0 kV
SEM MAG: 500 x
VEGA3 TESCAN
WD: 15.41 mm
Det: SE
100 μm
View field: 554 μm
Date(m/d/y): 04/06/17
FT TUL Liberec

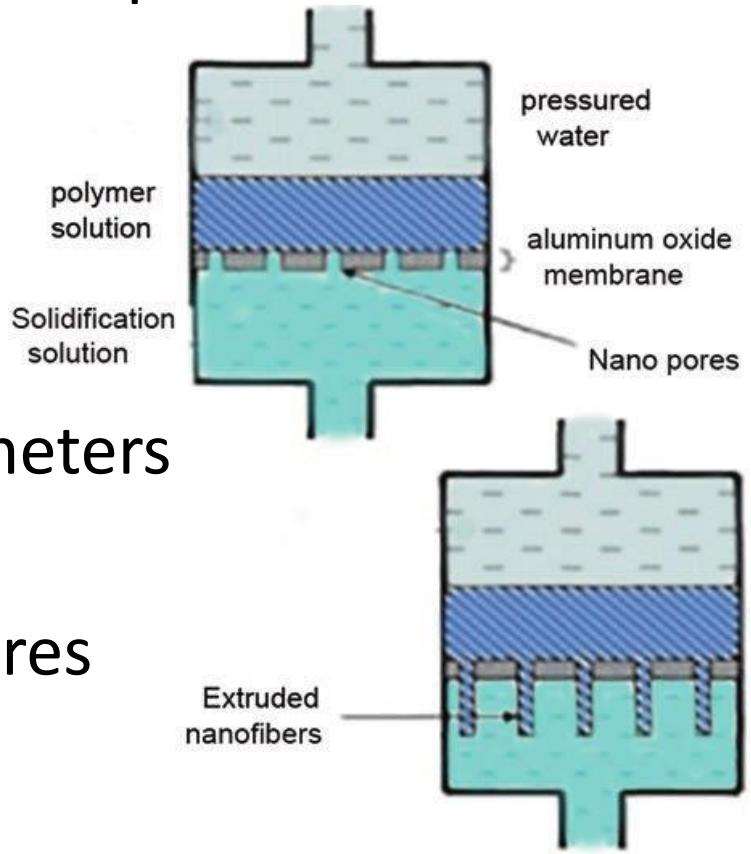
Drawing

- Use of oriented fiber scaffolds for nerve or muscle tissue

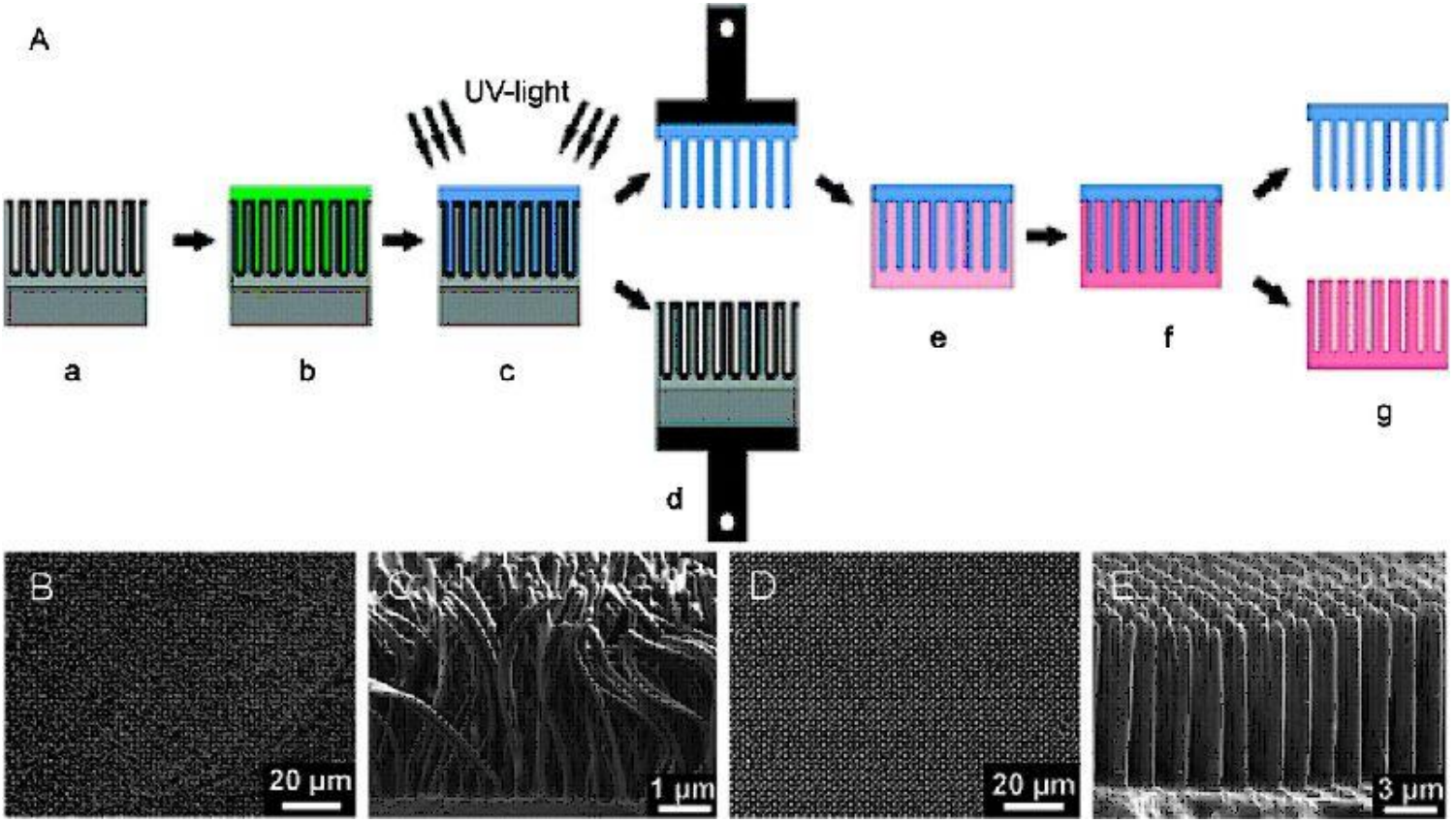


Synthesis by template

- Use of a template to obtain the required nanofiber materials
- Production of fibers and tubes
- Possibility to control fiber diameters
- The template contains nanopores



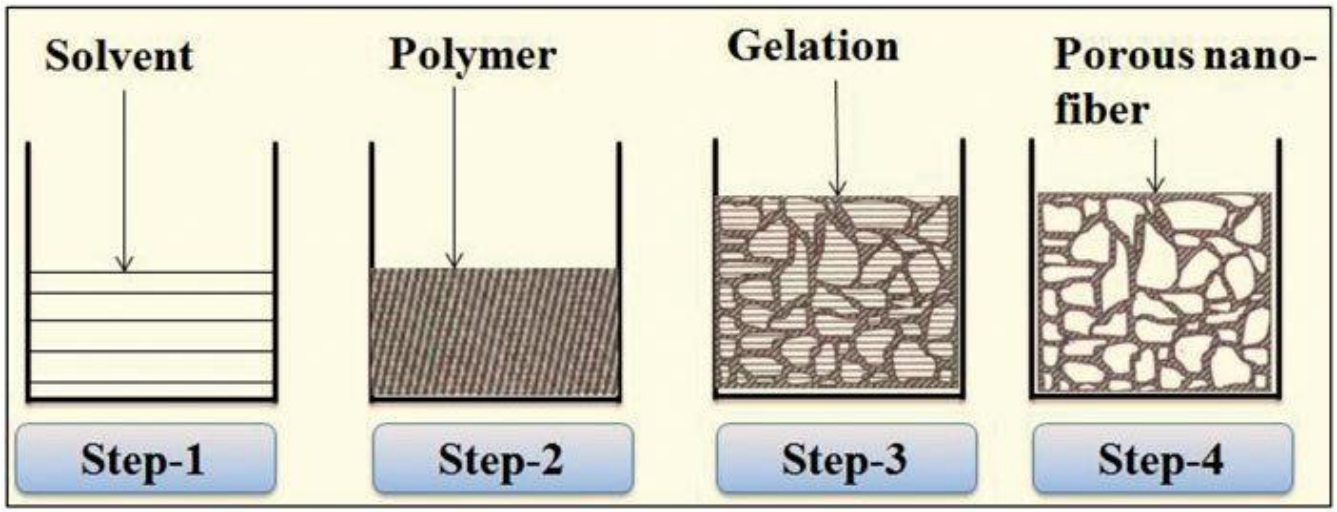
Synthesis by template



A) Schematic of the fabrication of polymer nanofibers using a nondestructive templating technique (grey: alumina template, green: resin, blue: polymer nanofibers, pink: silica replica template. (B-E) SEM images of 120 nm (b&c) and 1µm (d&e) polymer fibers fabricated by the above technique

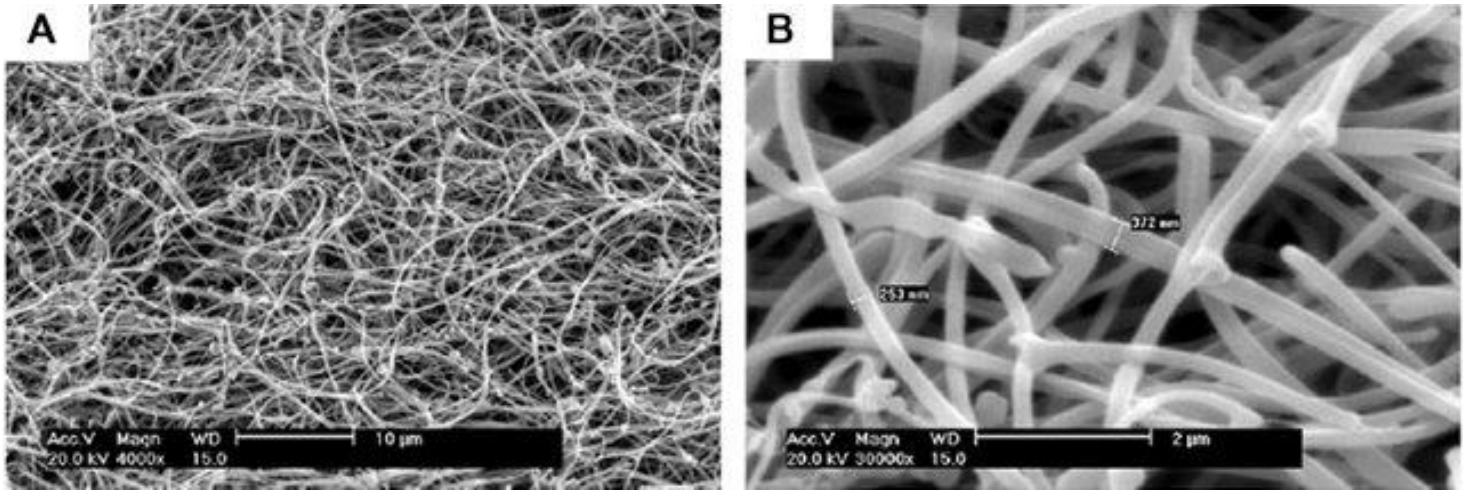
Phase separation

- The production method includes the steps of:
  - Forming a solution
  - Gelation
  - Wash the solvent
  - Lyophilization



Phase separation

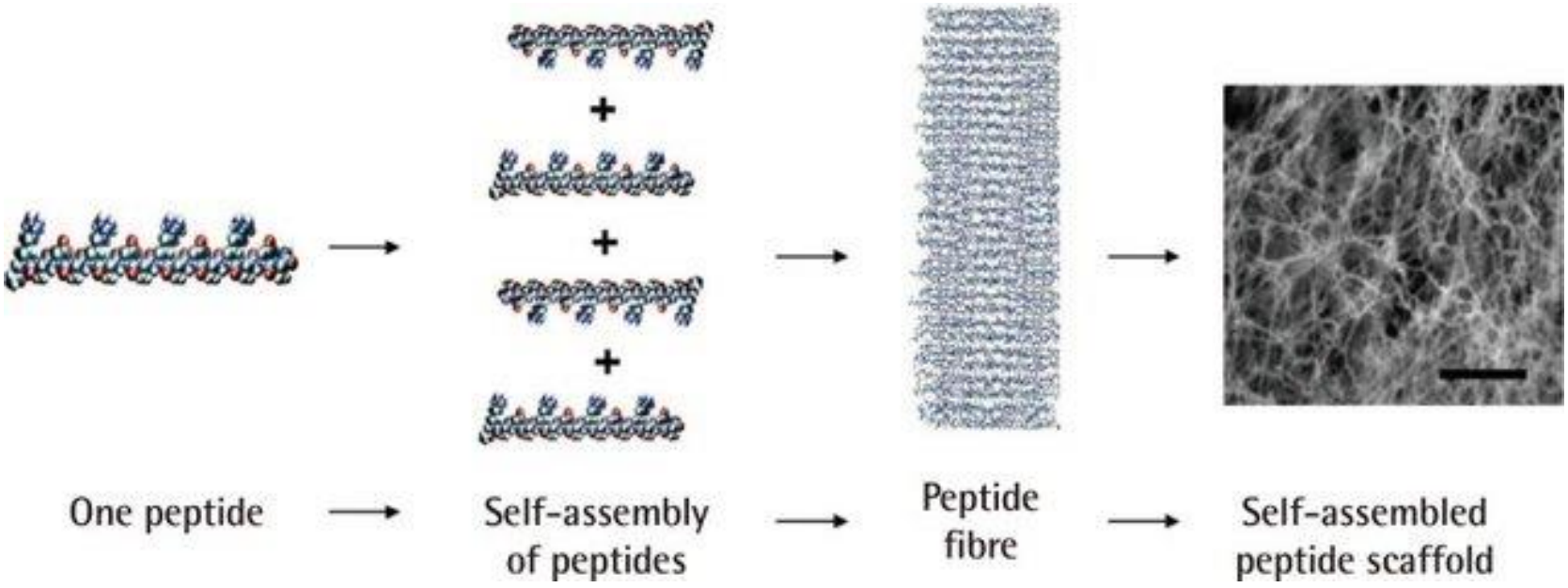
- Fiber diameters cannot be controlled
- A bulky nanofibrous material is formed



Formation of PLLA scaffolds with phase-separation Scanning electron microscopy images of poly(L-lactide) (PLLA) scaffolds produced using the phase-separation technique. (A) 500×, (B) 20,000× magnification (scale bars are 50 µm and 1 µm, respectively)

Self-assembly

- Nanofibers are formed by joining individual molecules through non-binding interactions
- Fiber diameters cannot be controlled



Comparison

Technology	Production	Fiber diameter
Electrospinning	Indrustrial	over 50 nm
Centrifugal spinning	Indrustrial	over 200 nm
Melt-blown	Indrustrial	over 150 nm
Bicomponent fibers	Indrustrial	over 500 nm
Drawing	Laboratory	2 – 100 nm
Synthesis by template	Laboratory	approx 100 nm
Phase separation	Laboratory	50 – 500 nm
Self-assembly	Laboratory	10 – 100 nm

Thank you for your attention!

TEST

- What are the methods of nanofiber production?
- What melt flow index is used for melt-blown technology?
- How are nanofibers created by drawing technology?
- What methods can be used to produce bulky nanofiber material?