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_AC spinning

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NextGenerationEU

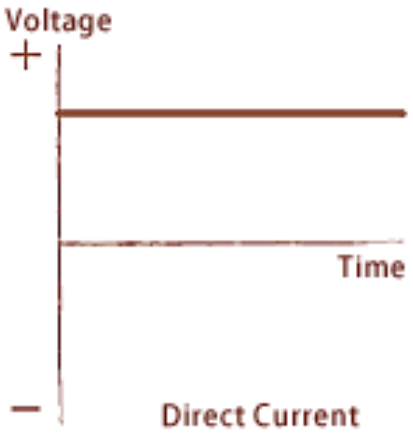
CZECH RECOVERY PLAN

MINISTRY OF EDUCATION, YOUTH AND SPORTS

Repetition

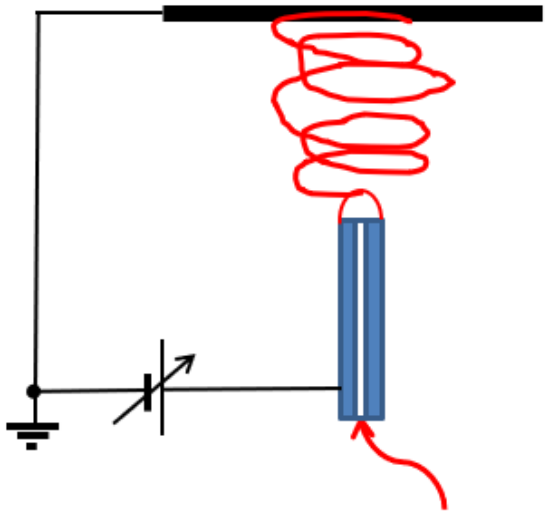
Electrostatic spinning

- Needle x needleless
- It uses a high voltage DC source
  - It does not change its polarity over time
  - Positive / negative

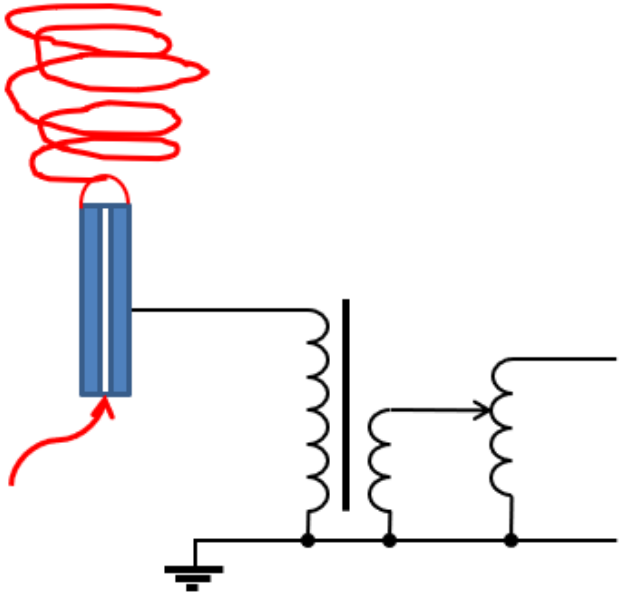


Comparison of DC and AC spinning

DC spinning
Requires an electrically active collector



AC spinning
It does not require an electrically active collector

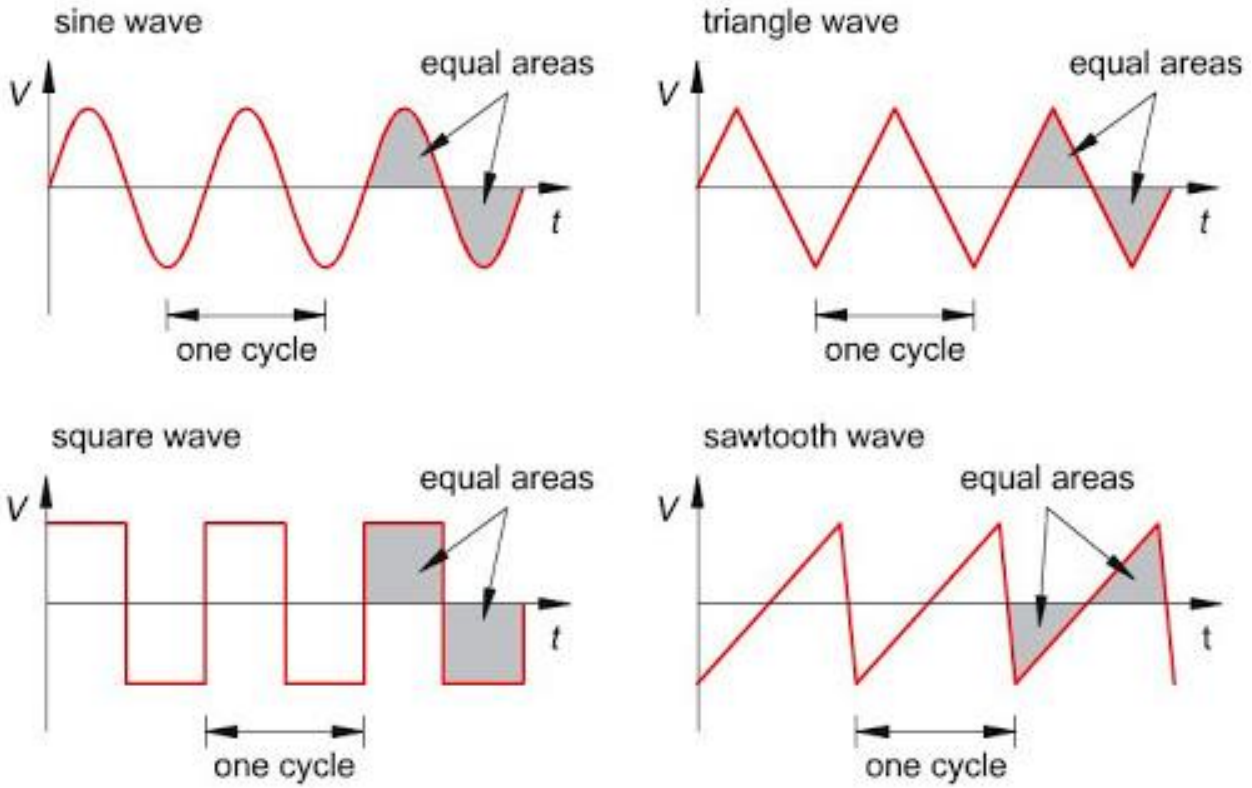


AC spinning

- It uses a high voltage AC source
  - It changes its polarity over time
- The fibers are charged with both positive and negative charges during the process
- There is no need for an electrically active collector, the emitted fibers serve as a collector
- The fibers are carried away from the electrode by an electric wind

AC spinning

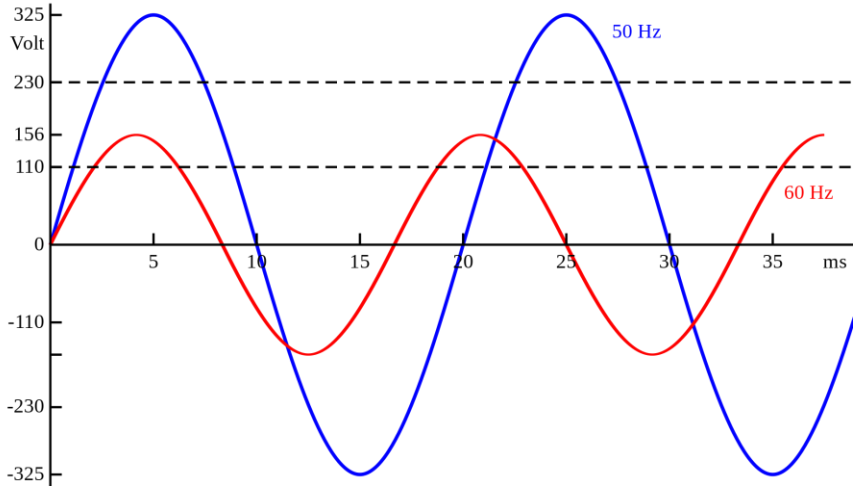
- Most often a harmonic course - sinusoidal
- Possibility to control the transmitted signal



AC spinning

- Possibility of control of frequency during AC spinning
- Frequency - the number of repetitions of a periodic event per unit time $f\ [Hz]$
- Period - duration of one repetition of a periodic event $T\ [s]$

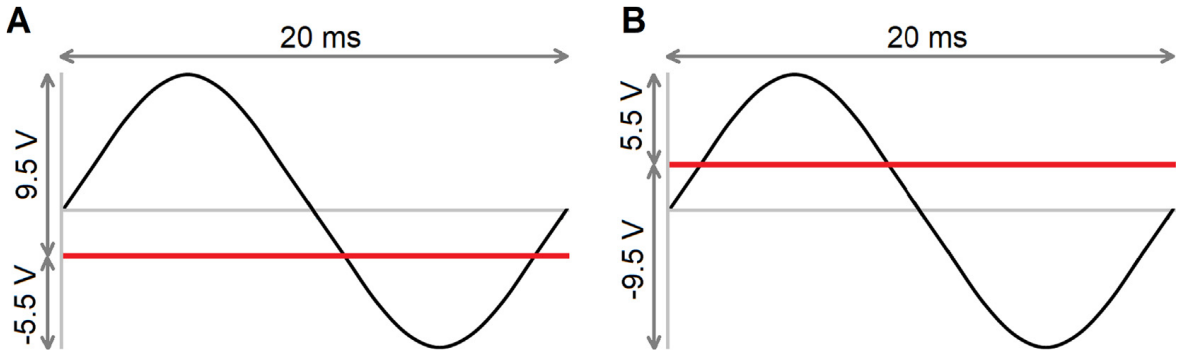
$$f = \frac{1}{T}$$



AC spinning

- Option to shift the offset

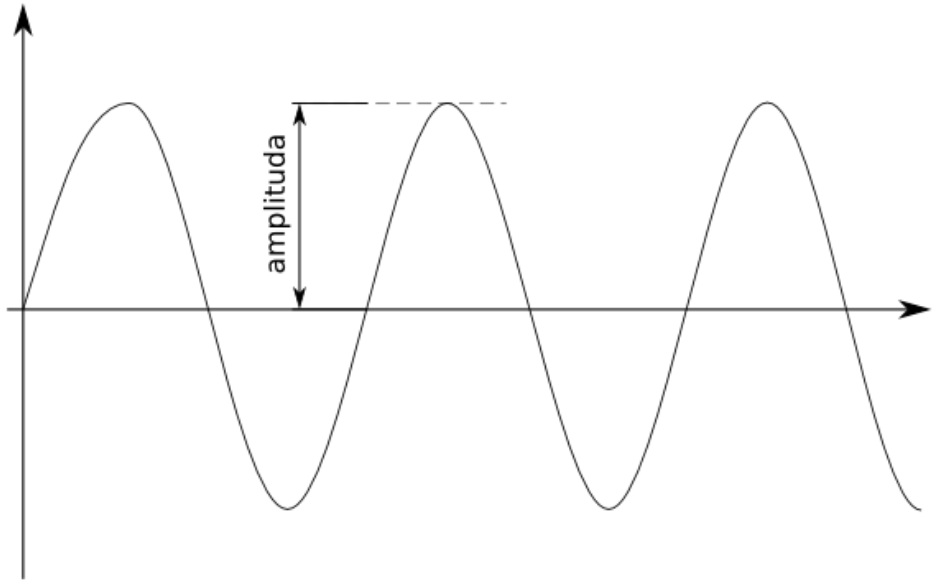
- Fibering takes place mainly in the positive or negative part of the transmitted signal



Transmitted signals with a shifted offset. (A) 9.5 V, -5.5 V, (B) 5.5 V, -9.5 V.

AC spinning

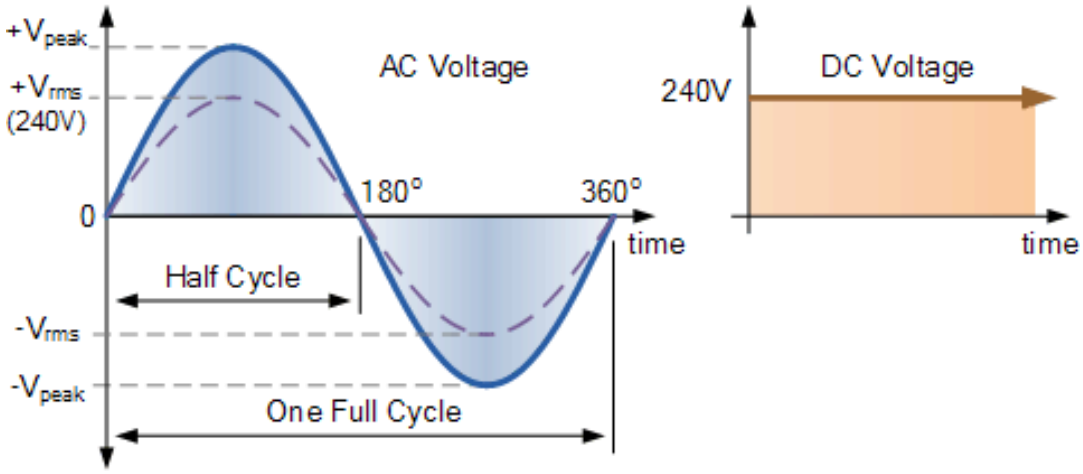
- Possibility of control of amplitude
- Amplitude - the maximum value of a variable value
- It affects the resulting effective voltage



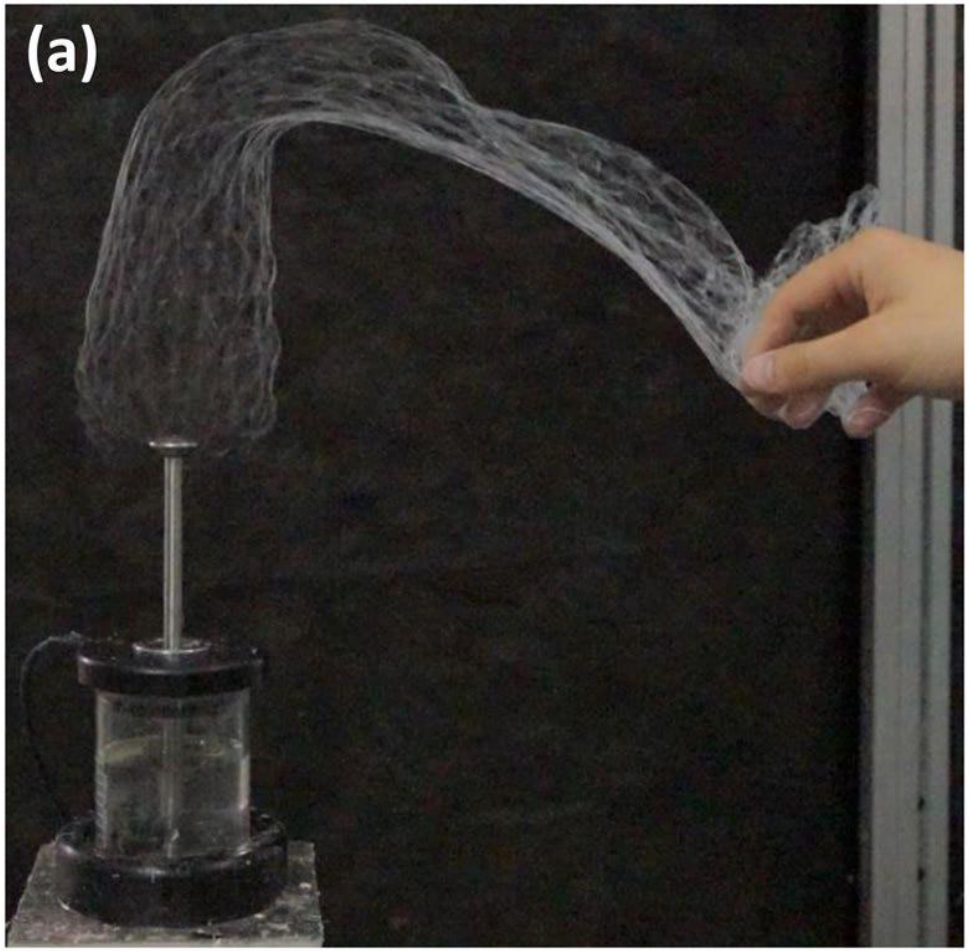
AC spinning

- The value of the AC voltage is constantly changing
- Effective value of AC voltage - equal to the value of DC voltage, which would give the same average power
- For a harmonic course:

$$U_{ef} = \frac{U_{max}}{\sqrt{2}}$$

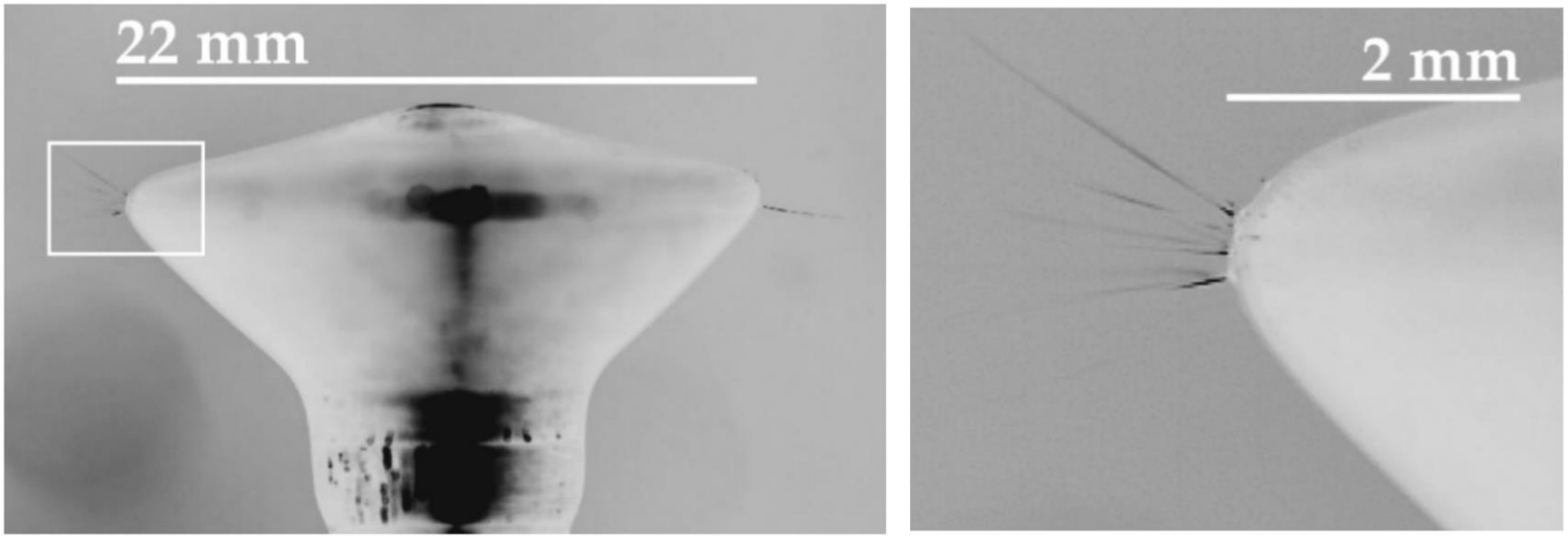


The process of AC spinning



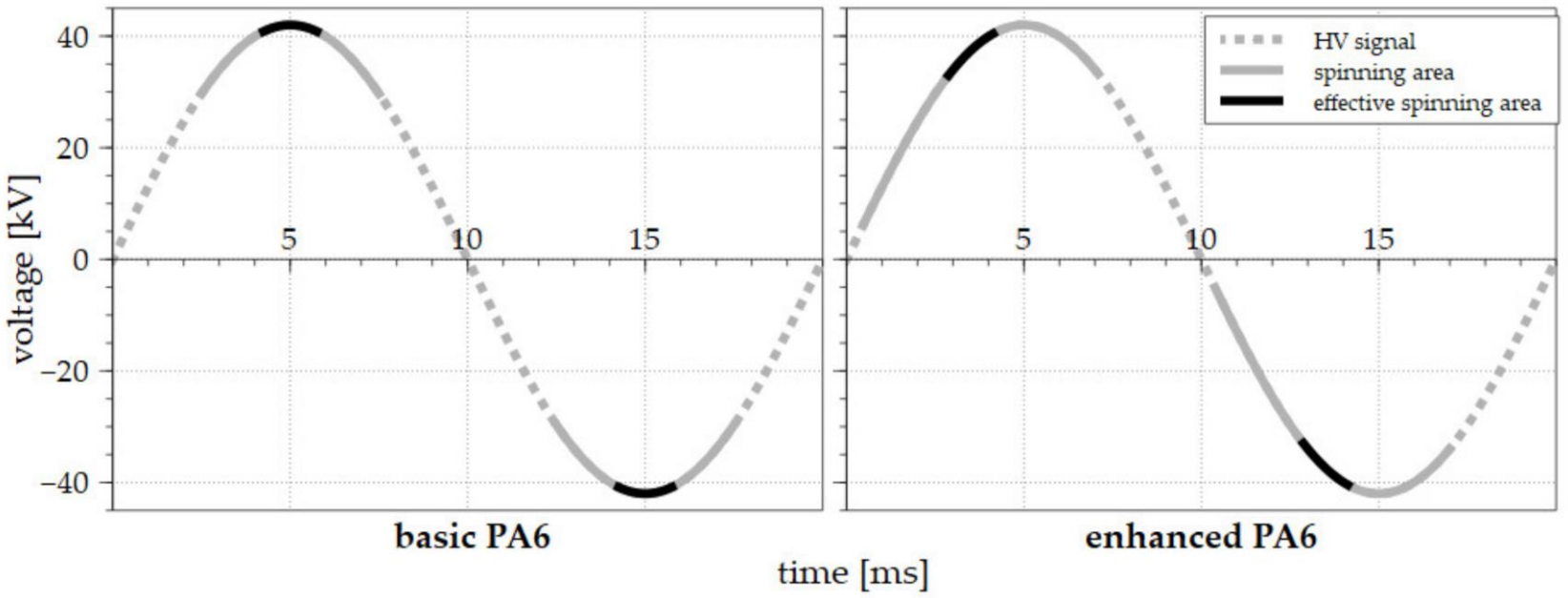
(**a**) The immediate product of AC electrospinning is a compact plume of nanofibres, which can be readily manipulated for further processing. The ability to grab and manipulate the plume by hand demonstrates that this method works without any electrically active collector. (**b**) The plume of nanofibres resembles fine smoke emerging from the AC electrospinning electrode. The spinning head of the electrode can be composed of three discs.

AC spinning process



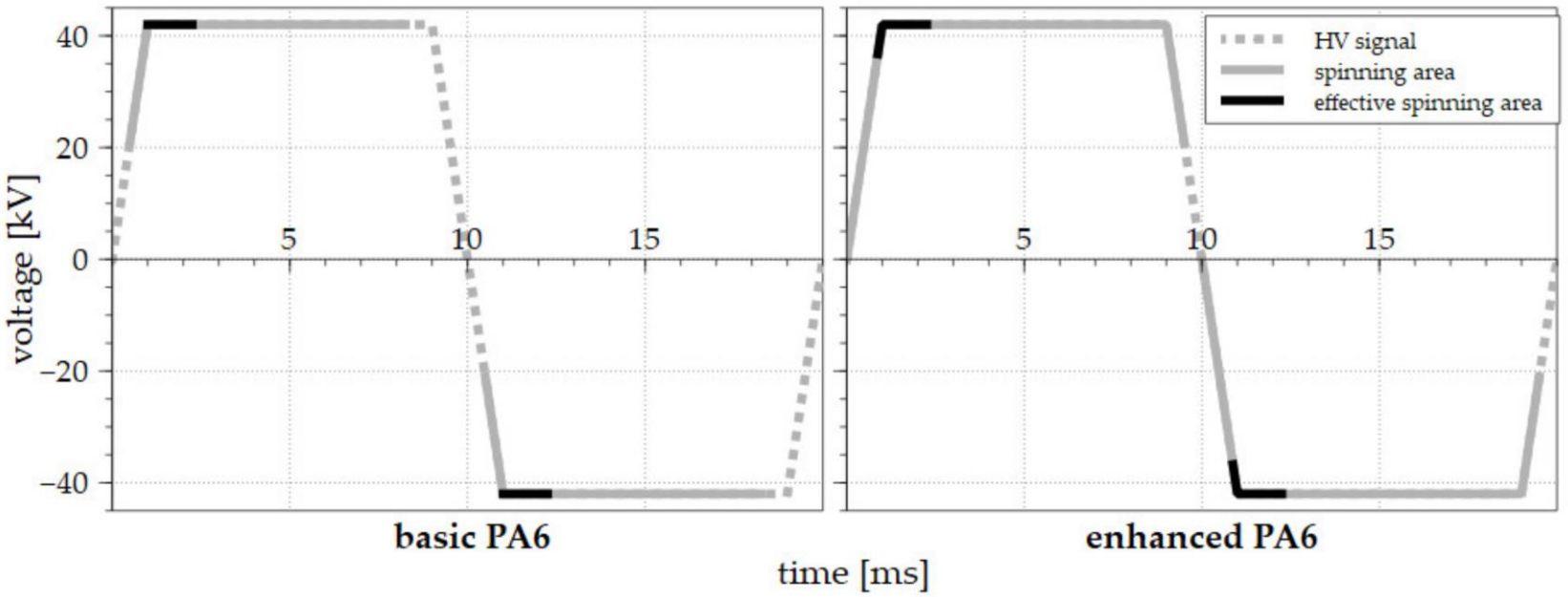
A disc-shaped steel overflow electrode (**a**) was used in the experiments. The white rectangle shows a detail of the edge (**b**) of the electrode on which the high-speed camera focused. The creation and subsequent collapse of the jets was observed and recorded only on the edge of the electrode tip due to the presence of the highest level of electrical intensity.

AC spinning process

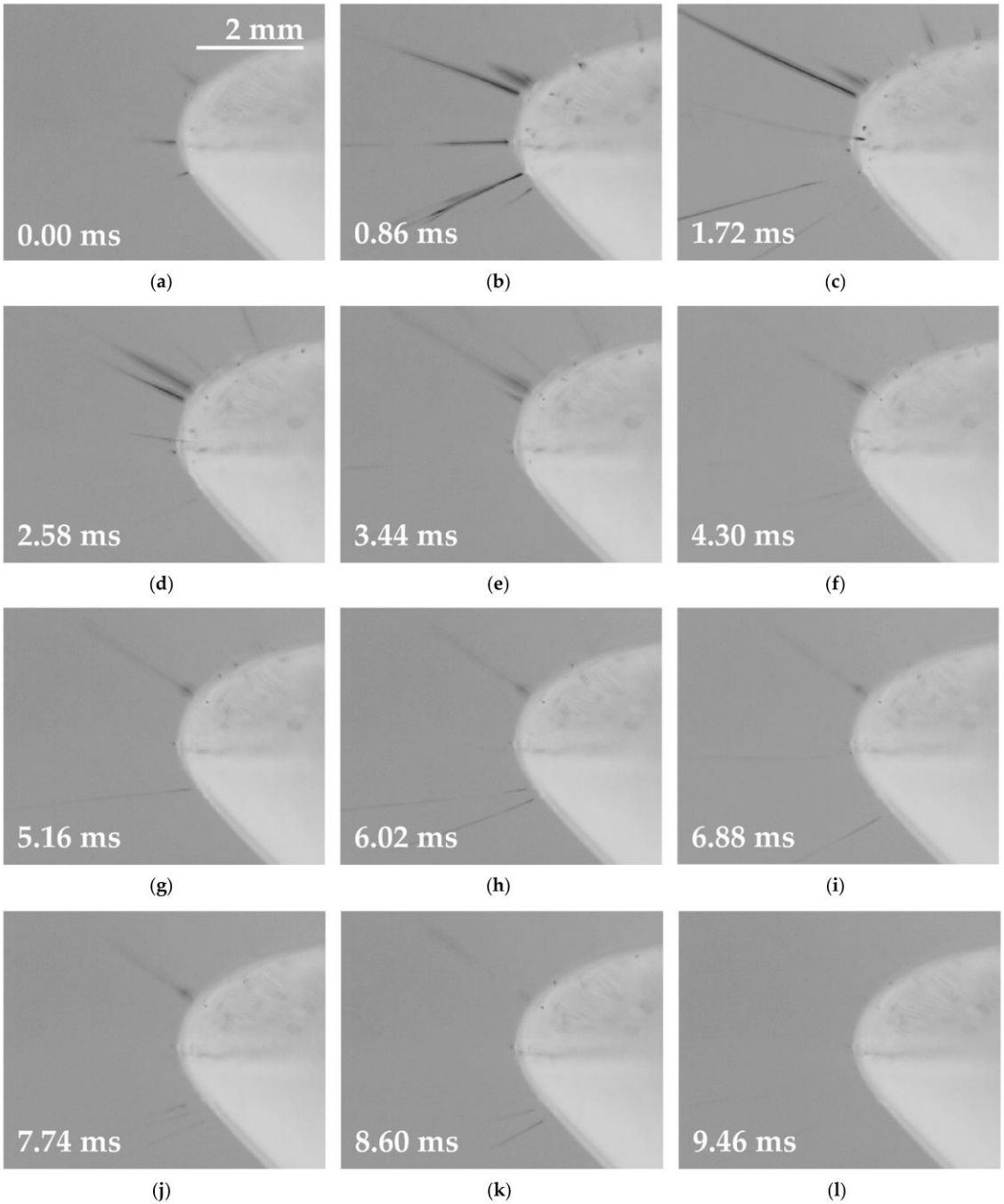


The AC electrospinning processes driven by the sinus wave signal for the basic PA 6 solution (**left**) and the enhanced solution (**right**). The voltage signals are represented by the dotted gray lines, the spinning areas are shown as a solid gray line, and the effective electrospinning areas are highlighted by solid black lines.

AC spinning process



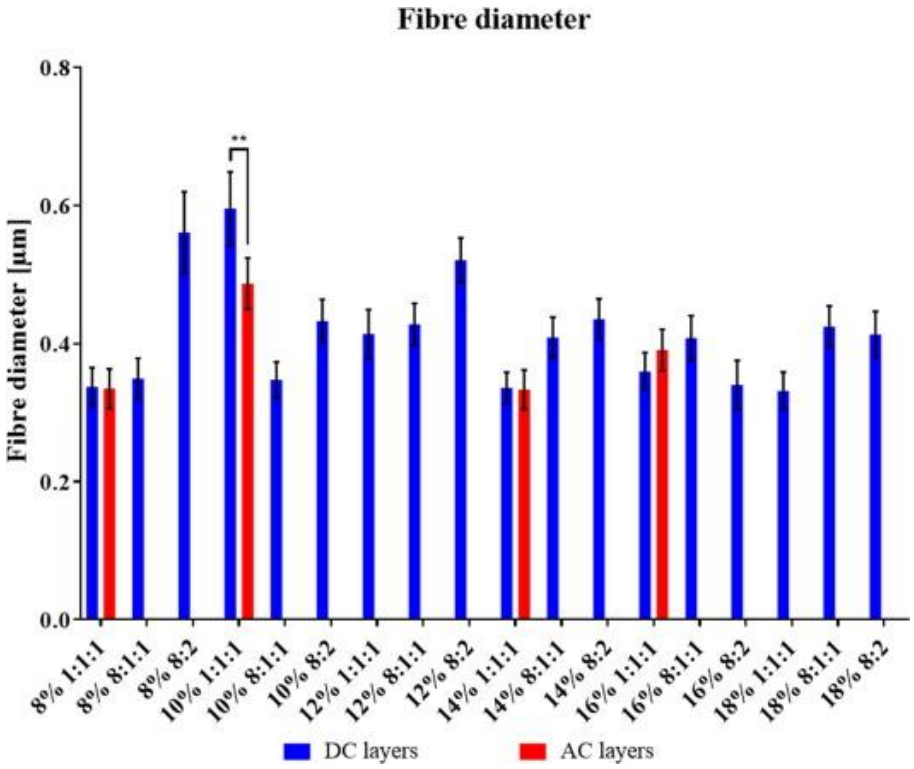
The AC electrospinning processes driven by the step change signal for the basic PA 6 solution (**left**) and the enhanced solution (**right**). The voltage signals are represented by the dotted gray lines, the spinning areas are shown as solid gray lines, and the effective electrospinning areas are highlighted by the solid black lines. The rising slope time was 1 millisecond.


2 mm
0.00 ms
(a)
0.86 ms
(b)
1.72 ms
(c)
2.58 ms
(d)
3.44 ms
(e)
4.30 ms
(f)
5.16 ms
(g)
6.02 ms
(h)
6.88 ms
(i)
7.74 ms
(j)
8.60 ms
(k)
9.46 ms
(l)

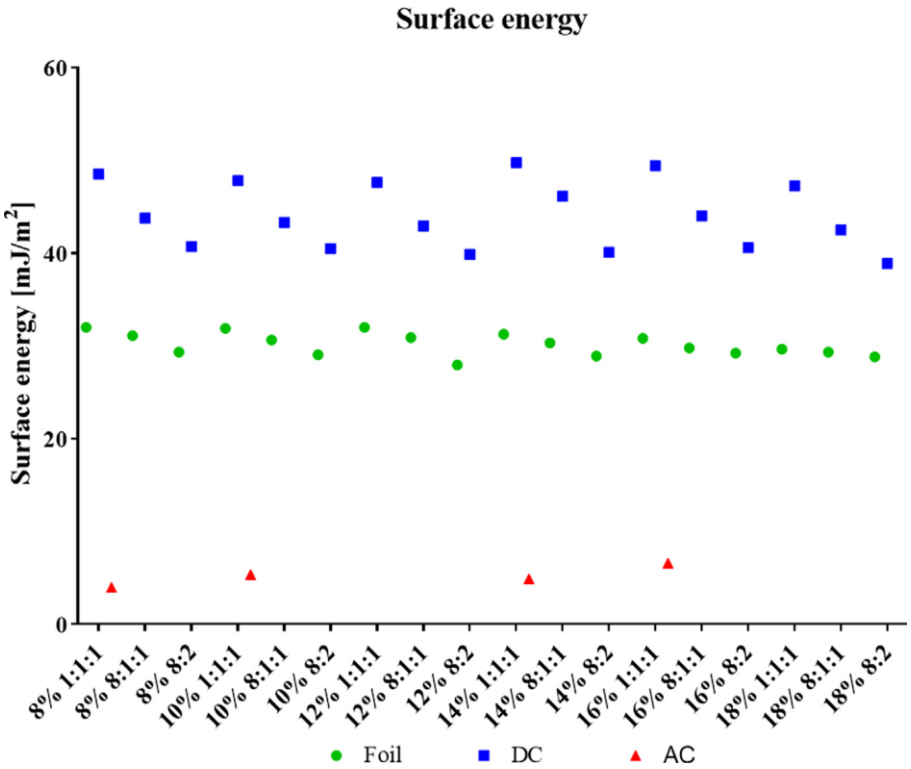
Evaluation

- Higher productivity than DC spinning
- Production of bulky layers
  - DC spinning - max. thickness approx. 600 µm
  - Alternating spinning - possible thickness up to several cm
- Problem:
  - They do not spin all polymers that spin by DC spinning
  - The same problem with the solvent system

Evaluation



Graph of fiber diameters for DC fiber layers and AC fiber layers



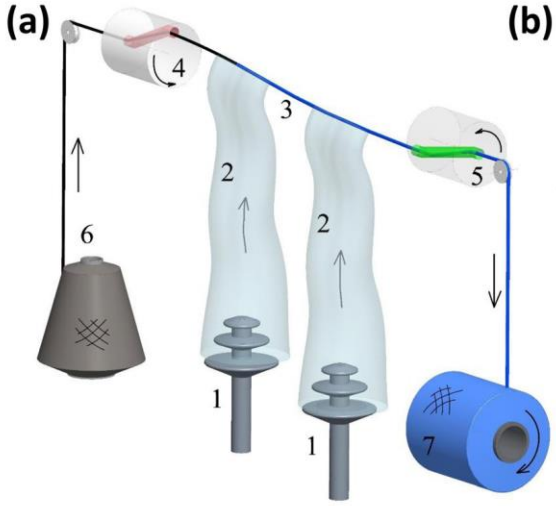
Surface energy values of the tested materials.

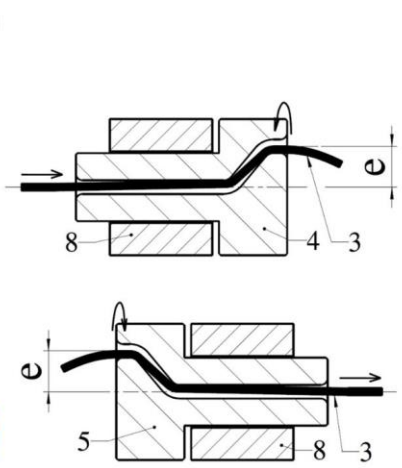
Use of AC spinning

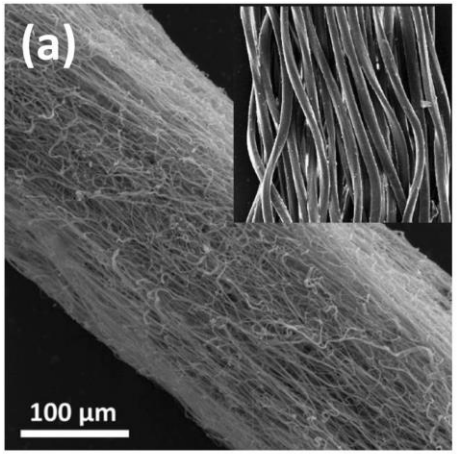
- Production:
  - Blended yarns
  - Core yarns
  - Flat materials
  - Composite sheet materials

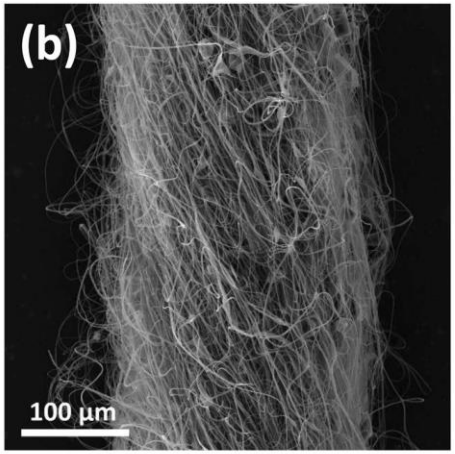
- The following can serve as a collector:
  - Yarn
  - Static collector
  - Rotating drum
  - Belt

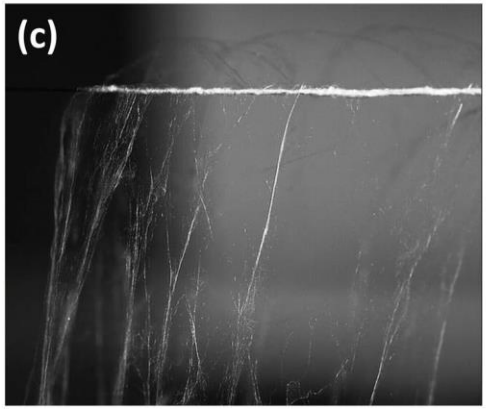
Core yarns

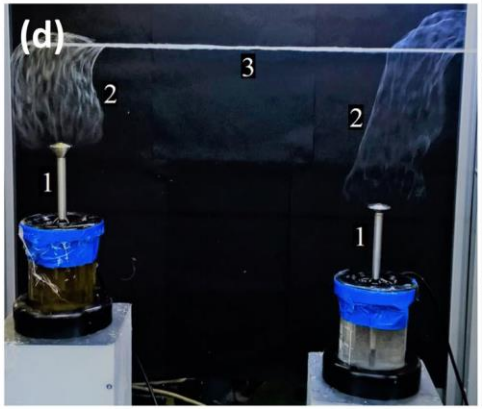


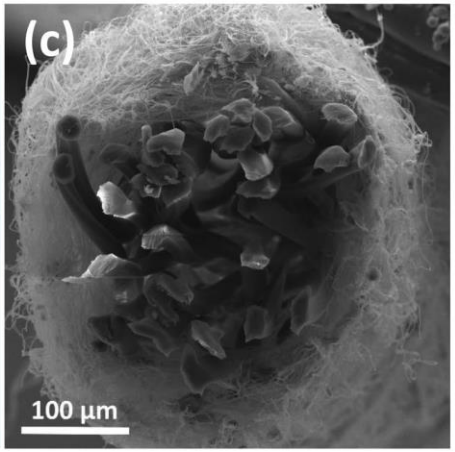


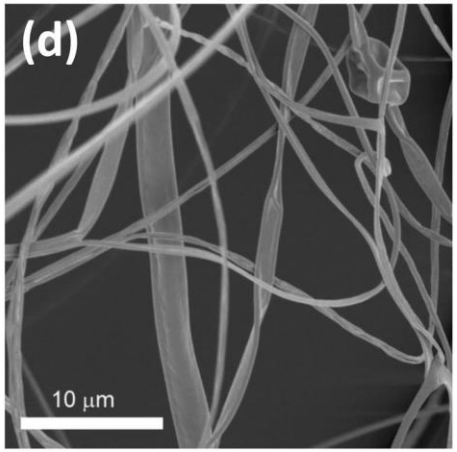




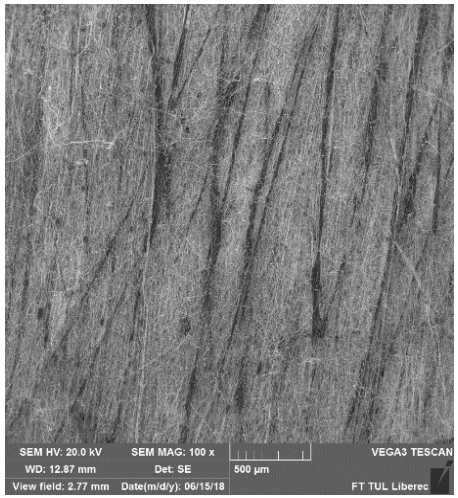


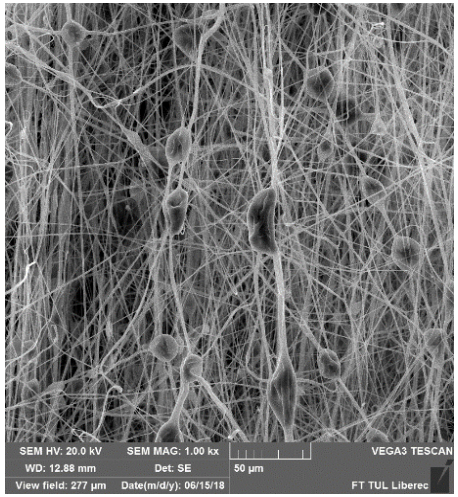




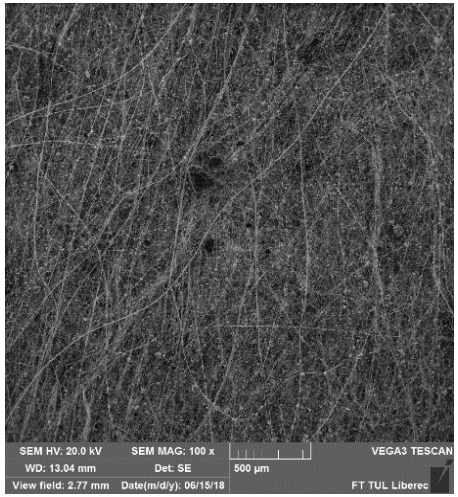


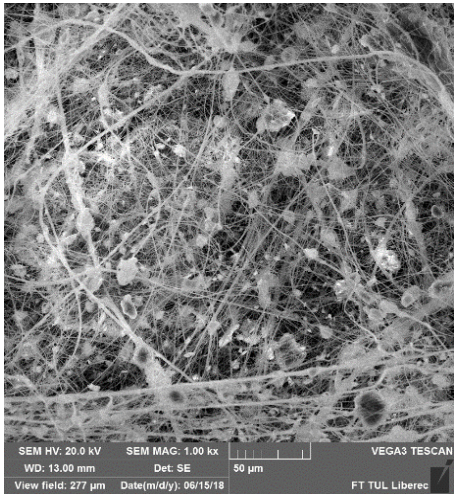
Flat materials





Composite sheet materials





Thank you for your attention!

TEST

- What is the difference between DC and AC spinning?
- What is the relationship between frequency and period?
- What is effective voltage?
- Is a collector needed for AC spinning?