Textilní chemie

13. Směsi vláken

Jakub Wiener

Jeden za všechny …

Jeden druh vlákna = jedny užitné vlastnosti … jedna cena … jedna ideální aplikace

polyester – ideální pro aplikace vyžadující vysokou pevnost, chemickou odolnost, dlouhou životnost, malou navlhavost, nemačkavost

bavlna – ideální pro vysokou navlhavost, smáčivost, bobtnavost, ekologičnost, barvitelnost, mačkavost, malá odolnost v oděru

Všichni za jednoho…

Vlákna se využívají velmi často v podobě směsí

Pro mechanickou technologii je to snadné – na chemickém složení vláken nezáleží. Jde to snadno, tak proč to nedělat. Bude to levnější. Bude to šikovnější pro některé aplikace.

Směsování vláken

Směsování je problém:

1) **Při chemické úpravě (zejména barvení) textilií**
2) **Při deklaraci složení textilie**
3) **Při údržbě textilií**
4) **Při recyklaci**
5) **Při analýze textilií**

směsování

Směsi vláken a komfort

Směsi vláken

Běžné směsi pro oděvní aplikace Polyester/bavlna, polyester/akryl, polyester/vlna a polyester/viskóza:

nemačkavý a odolný polyester se přidává k mačkavým přírodním vláknům (např. bavlně), výsledná tkanina je odolnější.

Praní: šetrný prací program, ruční praní nebo praní v pračce při 40 °C. Dopředu nenamáčejte. Neždímejte.

Žehlení: Žehlete opatrně.

Směsi vláken a hoření

Co z toho dokážete zapálit?

parafin

kevlar

svíčka

https://www.prohackovani.cz/pize-merino_14805-ocelove-seda/?gclid=EAIaIQobChMI5o-vmu3t5AIVE4bVCh0L4AH0EAQYAiABEgLxP_D_BwE

Směsi vláken a hoření

parafin

Kevlar

svíčka

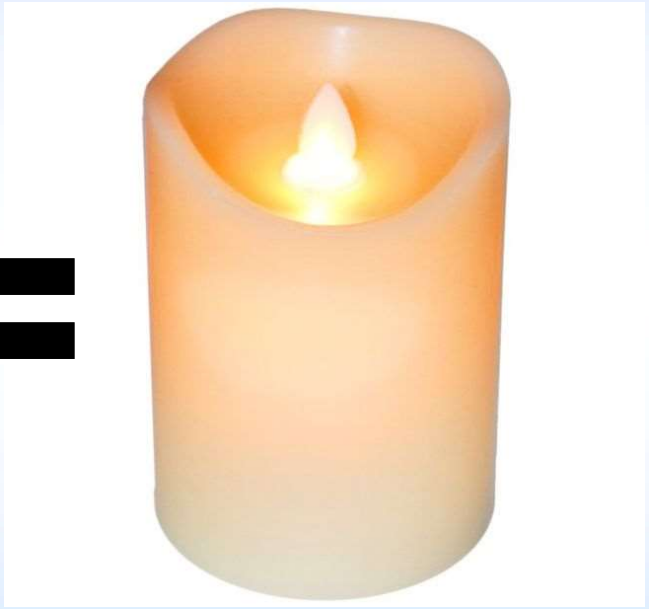
Směsi vláken a hoření

parafin

+

kevlar

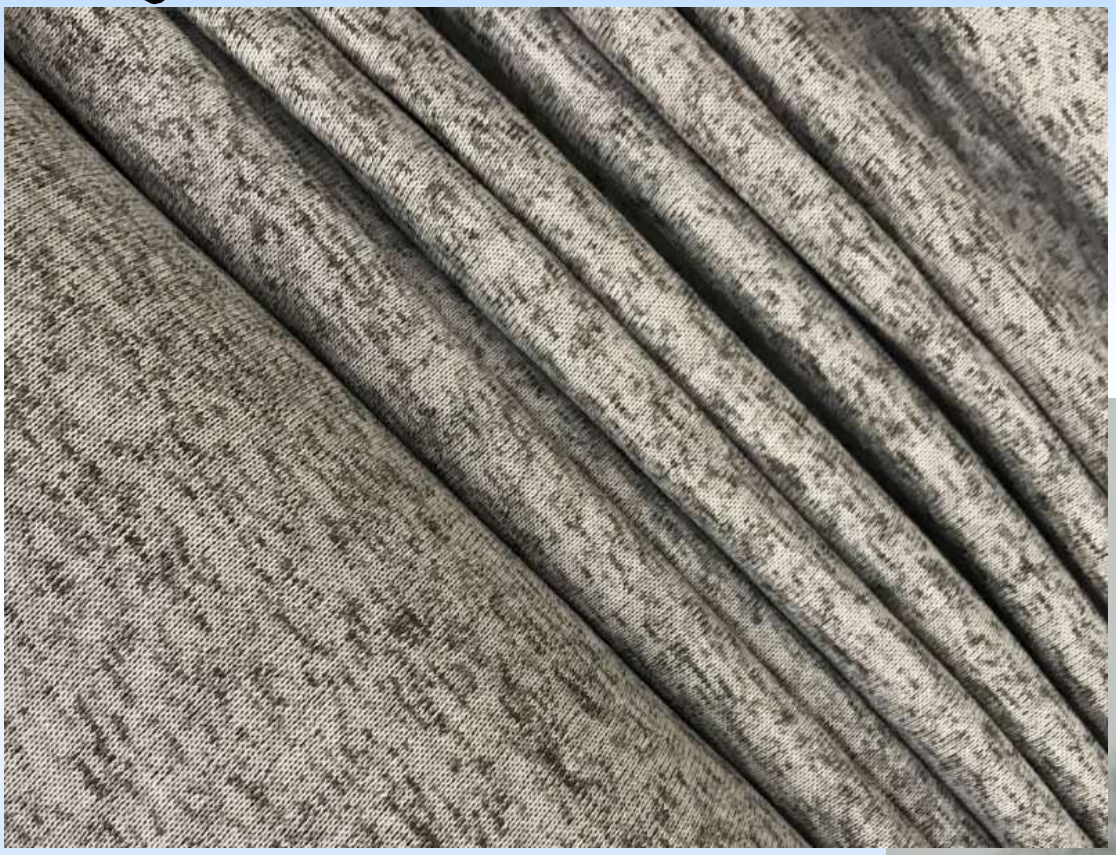
=



svíčka

Proč svíčka hoří???

Melanže

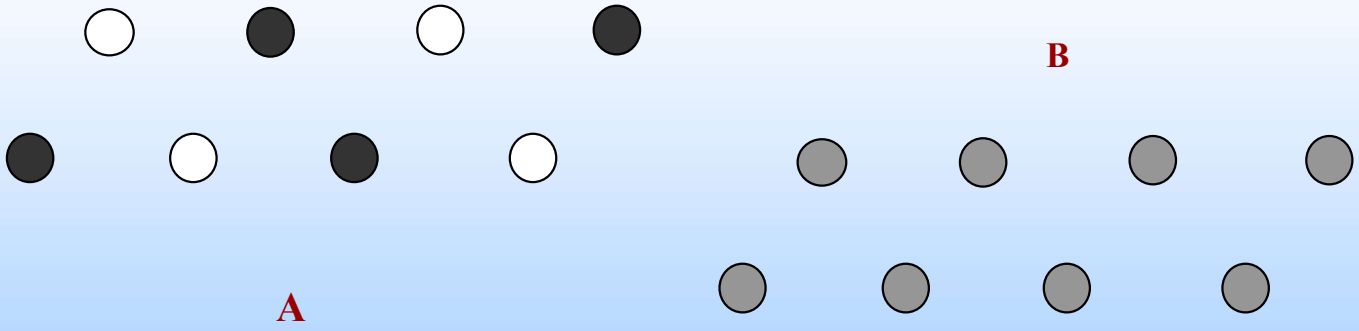


Směsování různobarevných vláken

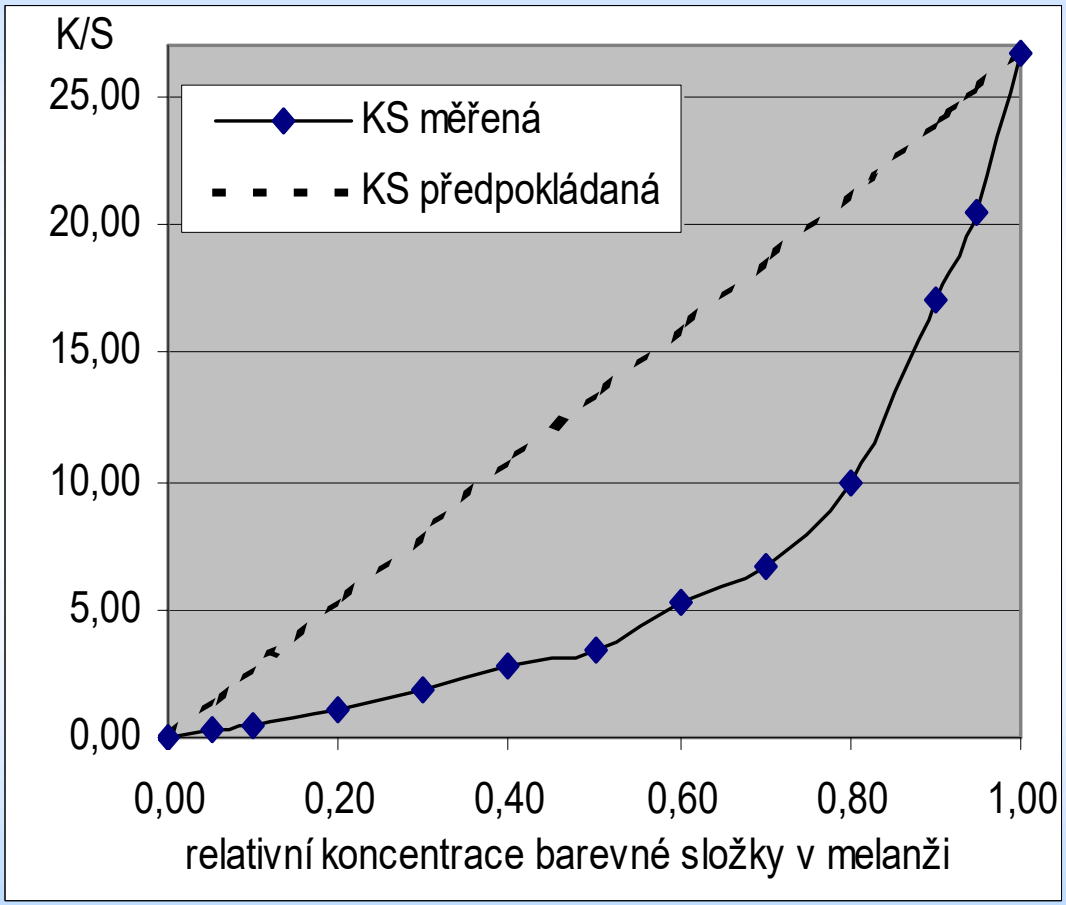
Zajímavý vzhled

Vliv melanžování na sílu odstínu

Pokud smícháme v poměru 1:1 barevná a nebarevná vlákna , bude výsledná směs jako celek obsahovat 50% barviva vůči textilii pouze z barevných vláken. Výsledná melanžová textilie bude výrazně světlejší, než by byla textilie obsahující stejné množství barviva rovnoměrně rozděleného mezi všechna vlákna



Vliv melanžování na sílu odstínu



K/S-hodnoty melanžové textilie jako funkce jejího složení - jedná se o směs černé a nebarvené viskózové střiže v různých poměrech – ve srovnání se stejnoměrně obarvenou viskózovou střiží na šedé až černé odstíny (čárkovaně – poskytuje lineární průběh).

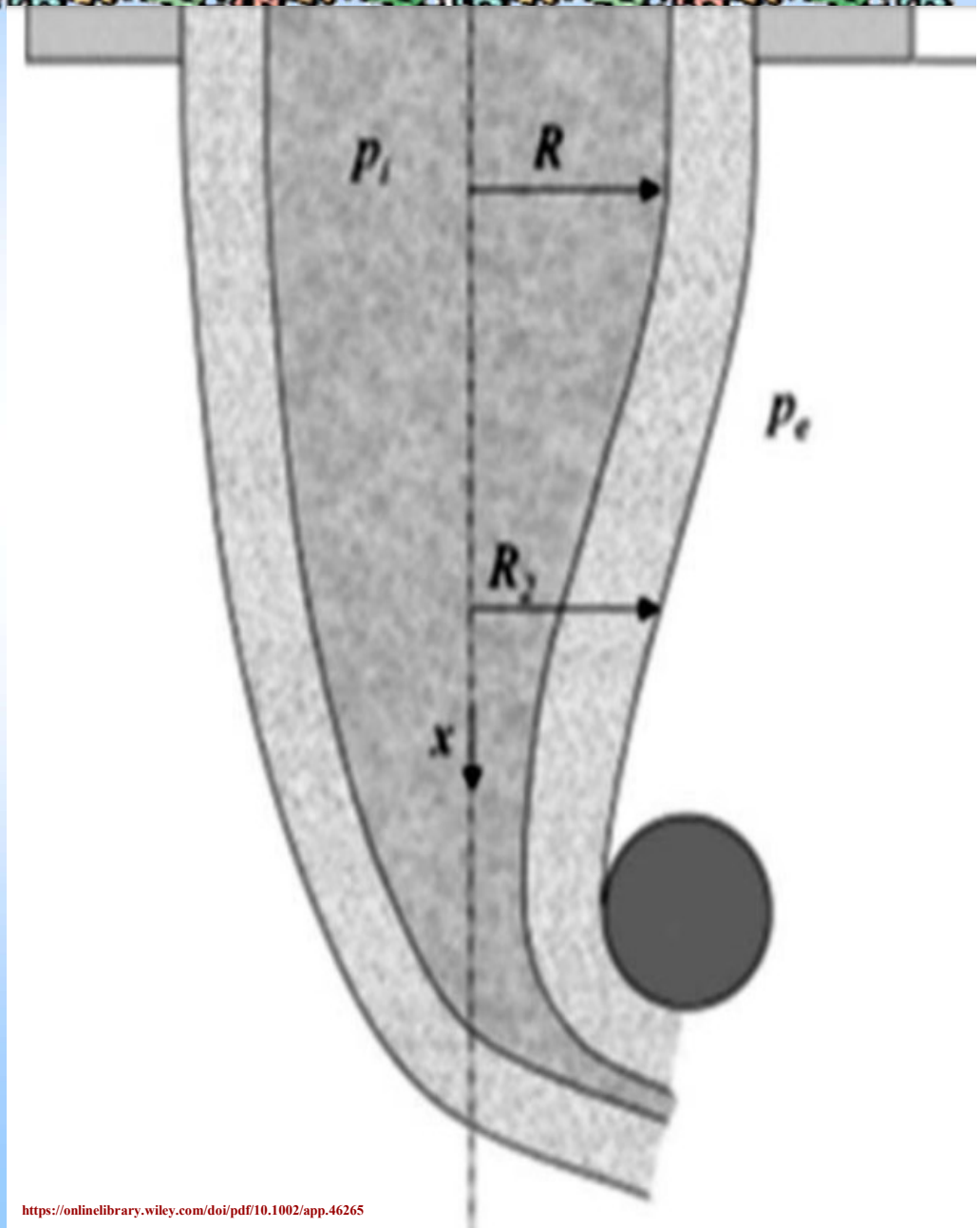
Bikomponentní vlákna

= směsování na úrovni polymerů

Jen pro tavitelné polymery

Princip: jednou zvlákňovací tryskou prochází současně několik polymerů tak, aby nedošlo k jejich smísení.

Lze použít polymerů s odlišnou teplotou tání, s rozdílnou polaritou, rozpustností …



https://onlinelibrary.wiley.com/doi/pdf/10.1002/app.46265

Užití bikomponentních vláken

Cíl:

Speciální průřezy vláken

Extrémně jemná vlákna

Pojivá vlákna (netkané textilie)

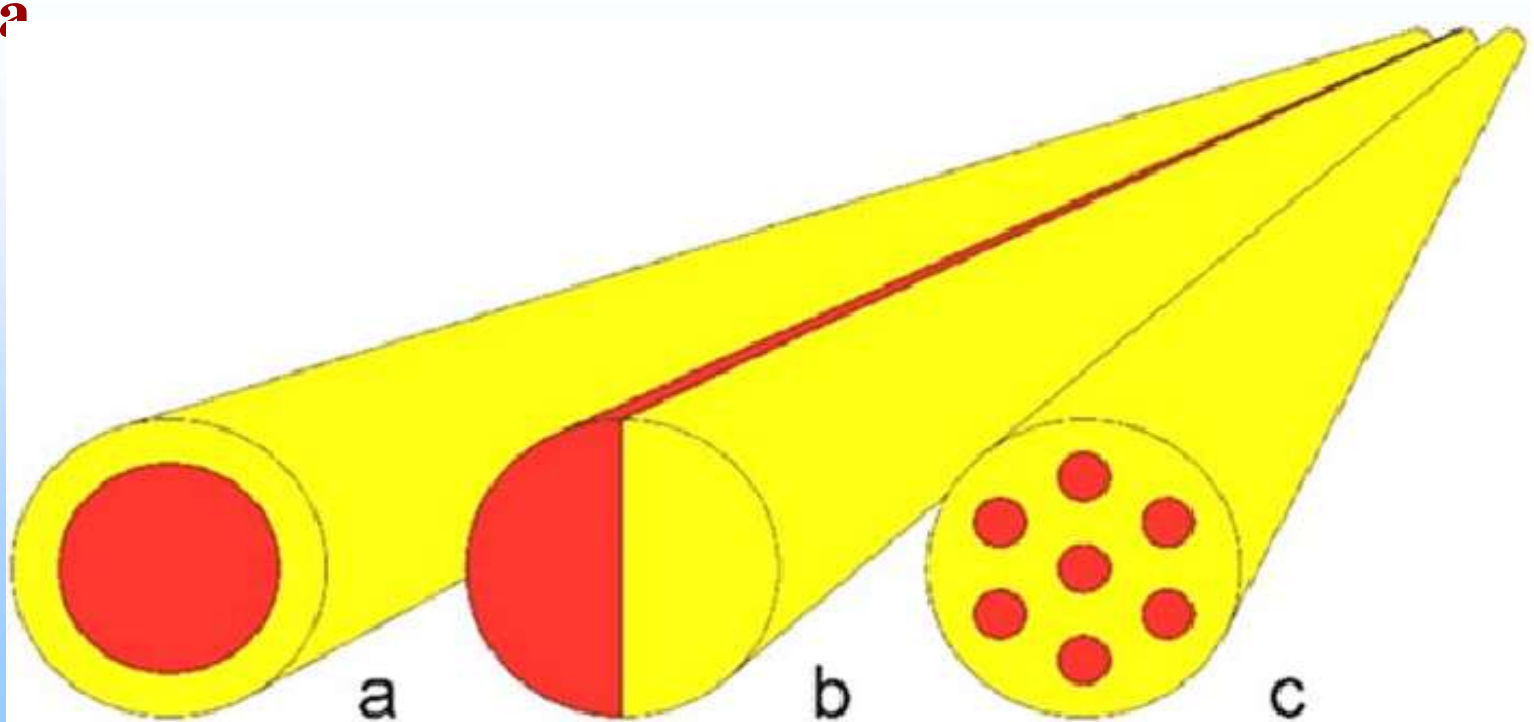
Barvitelnost vláken (PES v PP)

Optická vlákna

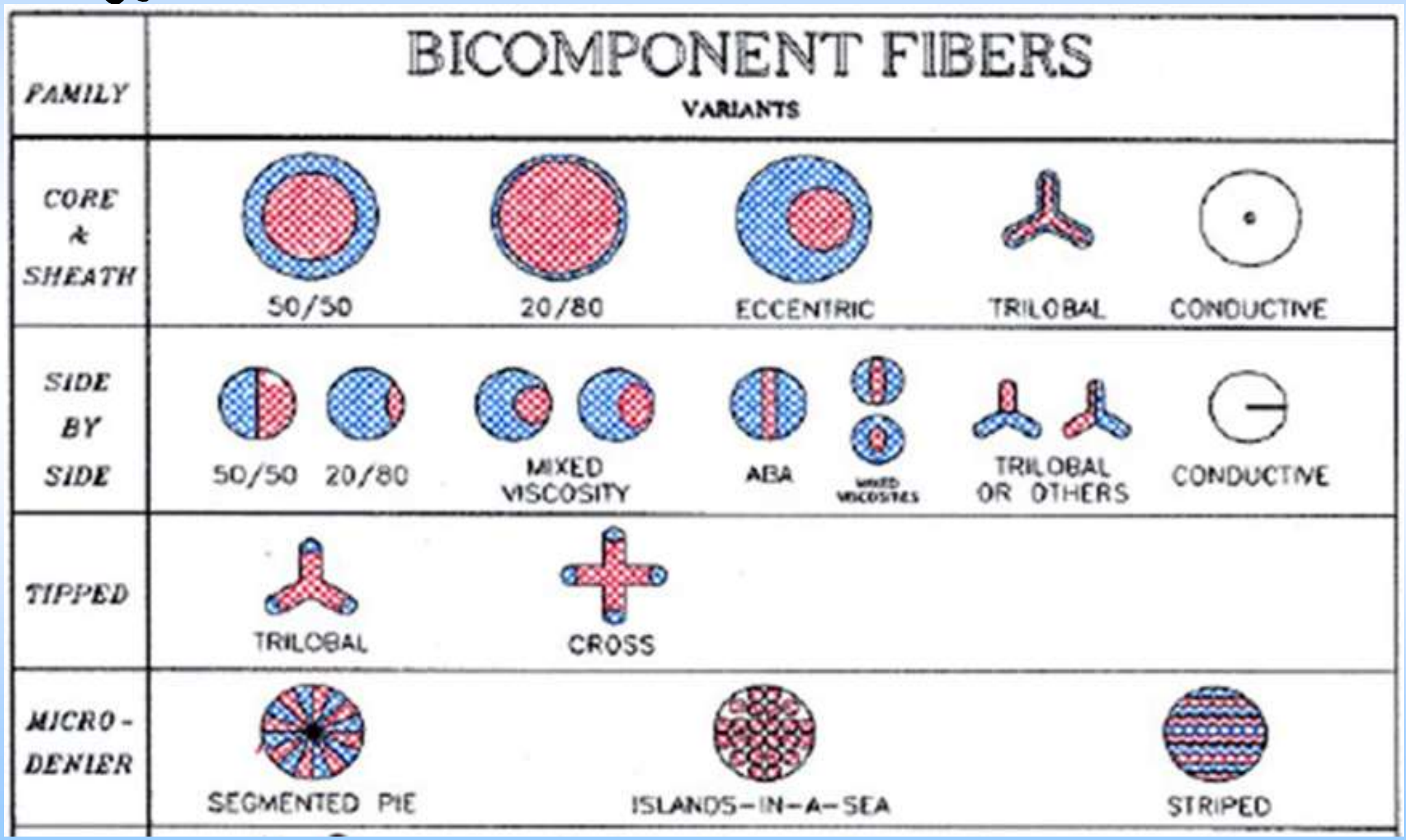
Biokompaktibilita

Obloučkovitost

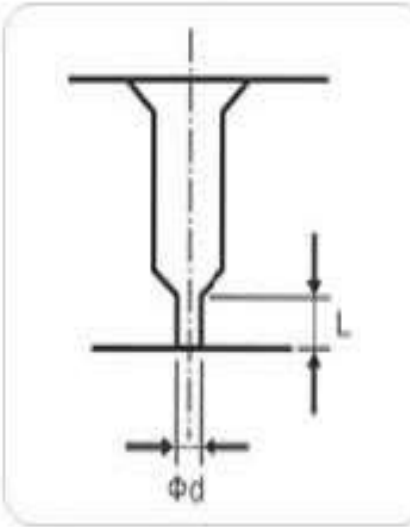
…



Druhy bikomponentních vláken

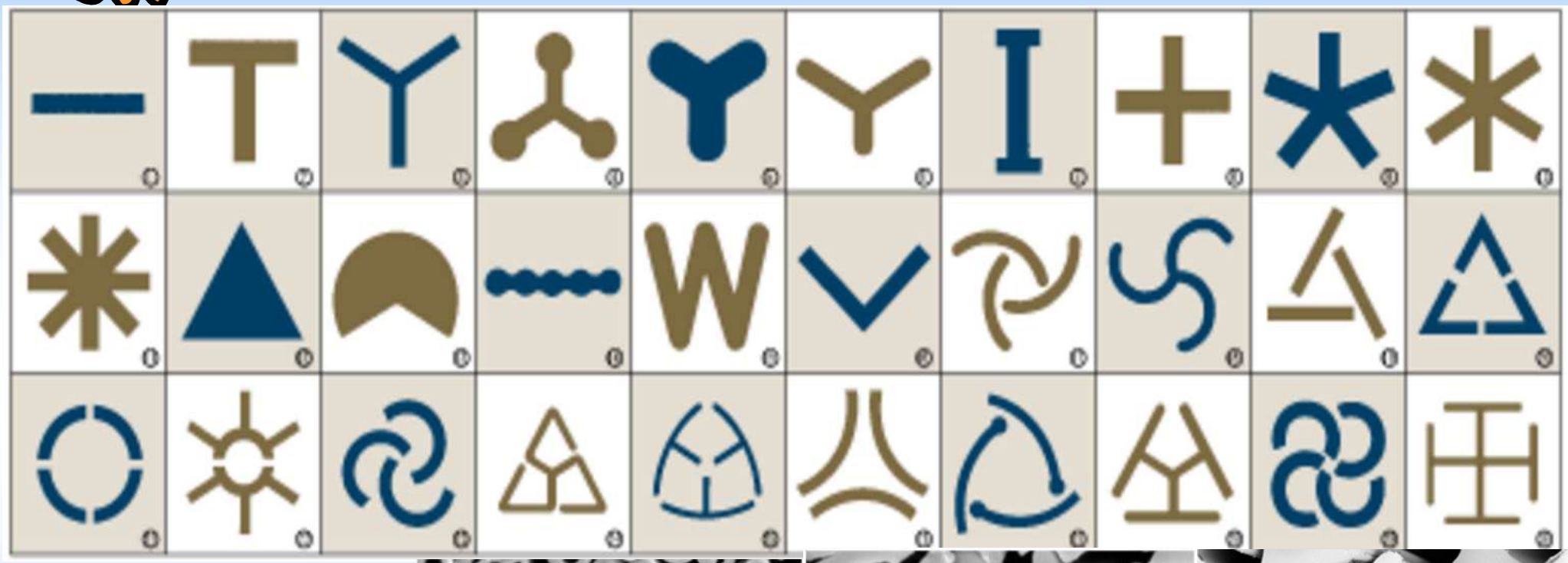


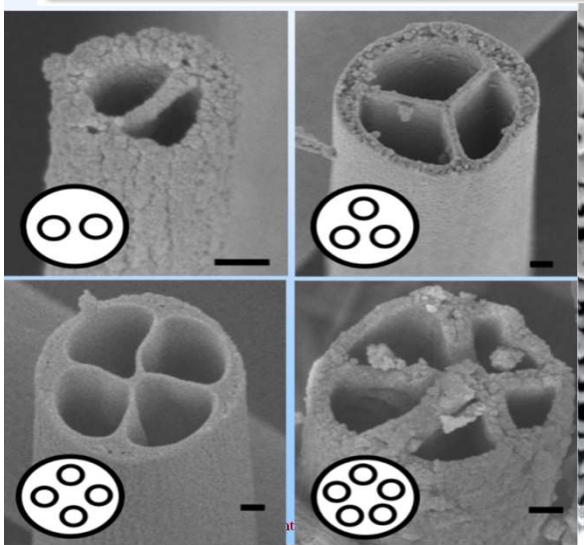
Výroba vláken

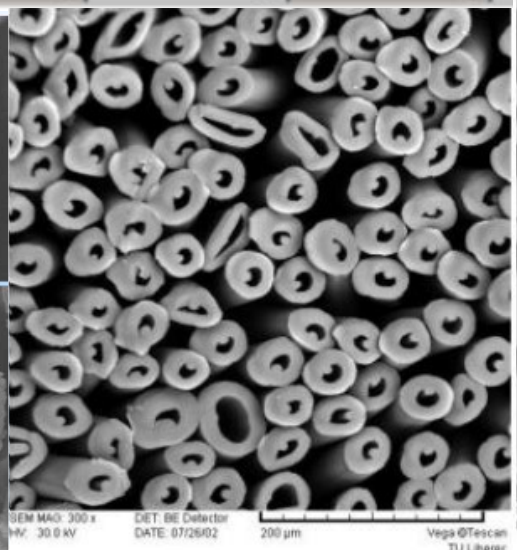


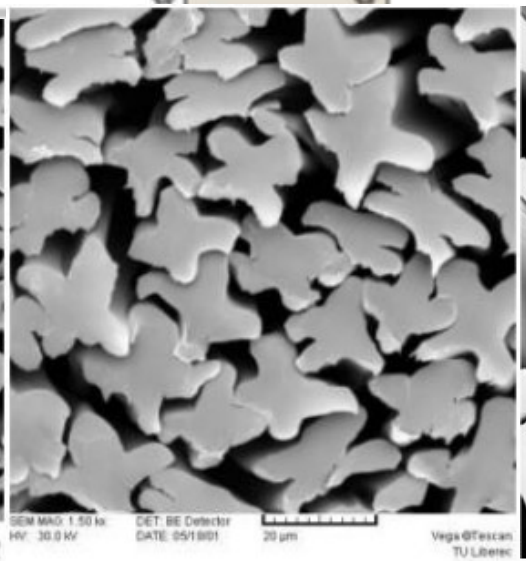
http://www.nippon-nz.com/en/product04.html

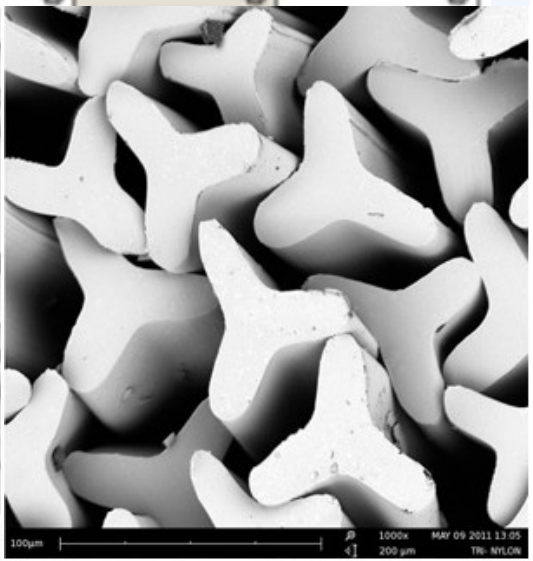
Trysky pro speciální průřezy vláken



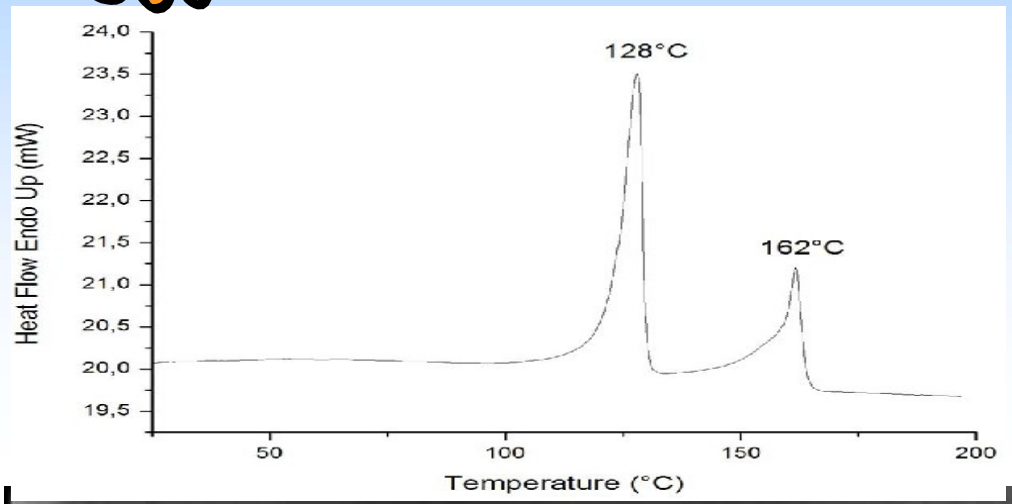




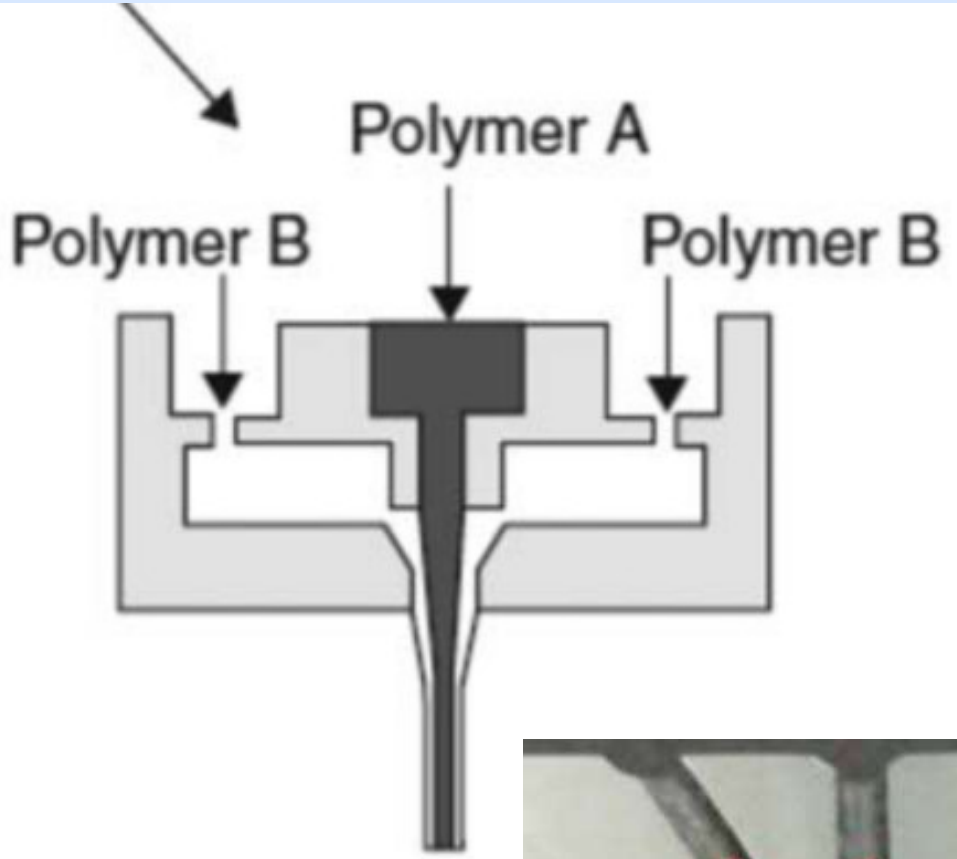


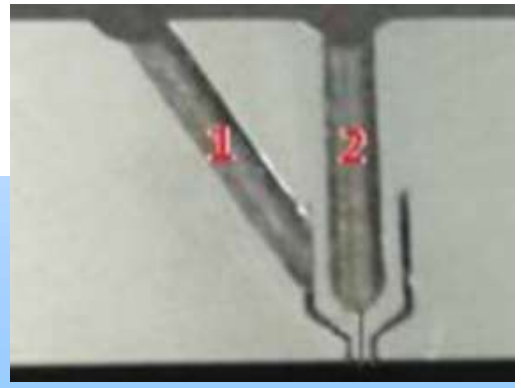


PE/PP bikomponentní vlákna pro pojení



Zvlákňovací hlava s trykou



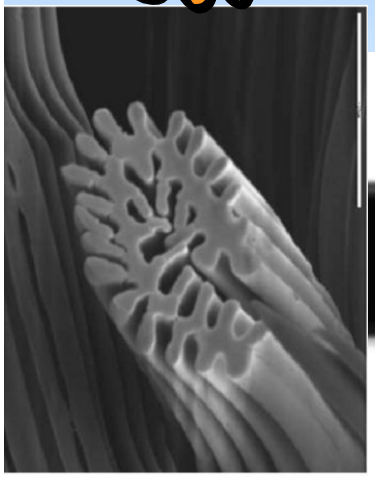


https://onlinelibrary.wiley.com/doi/pdf/10.1002/app.46265

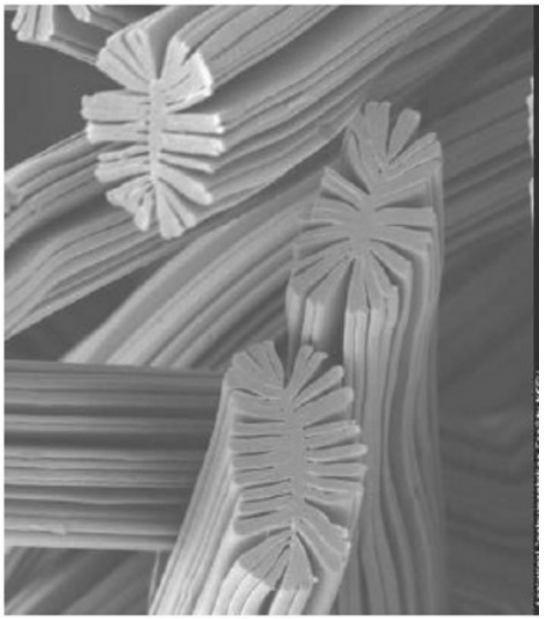
http://www.technicalnonwovens.com/product/bicomponents

https://www.researchgate.net/figure/DSC-thermogram-of-3-denier-PE-PP-bicomponent-fiber-nitrogen-second-heating_fig2_328128066

Bikomponentní vlákna pro filtrace

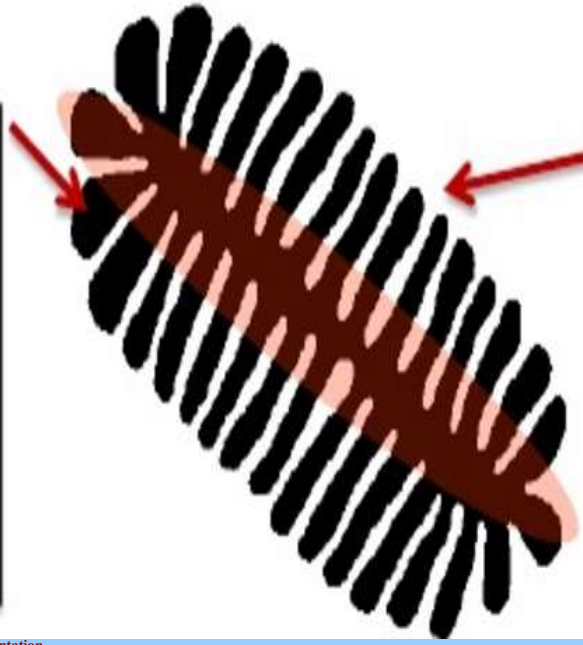


Sheath-Core Configuration



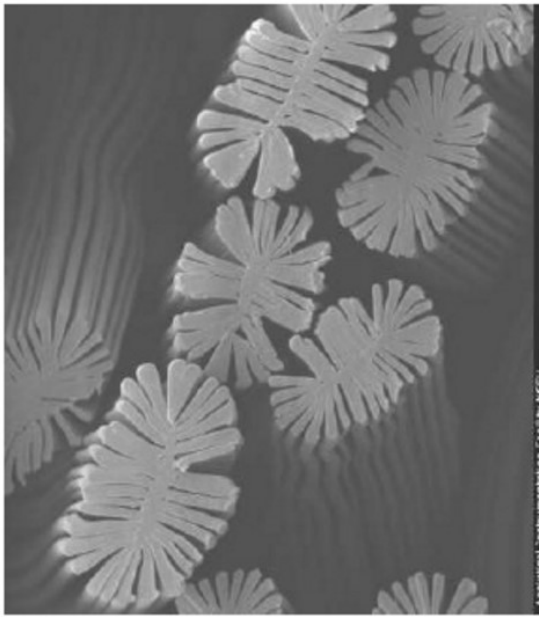
Core (Residual)

PP
PET
PA
PLA



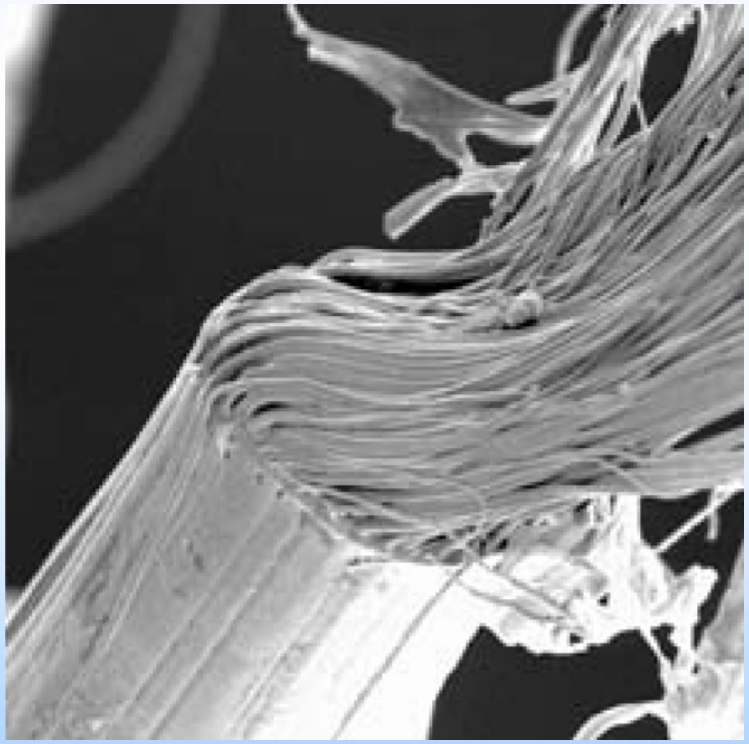
Sheath (Sacrificial)

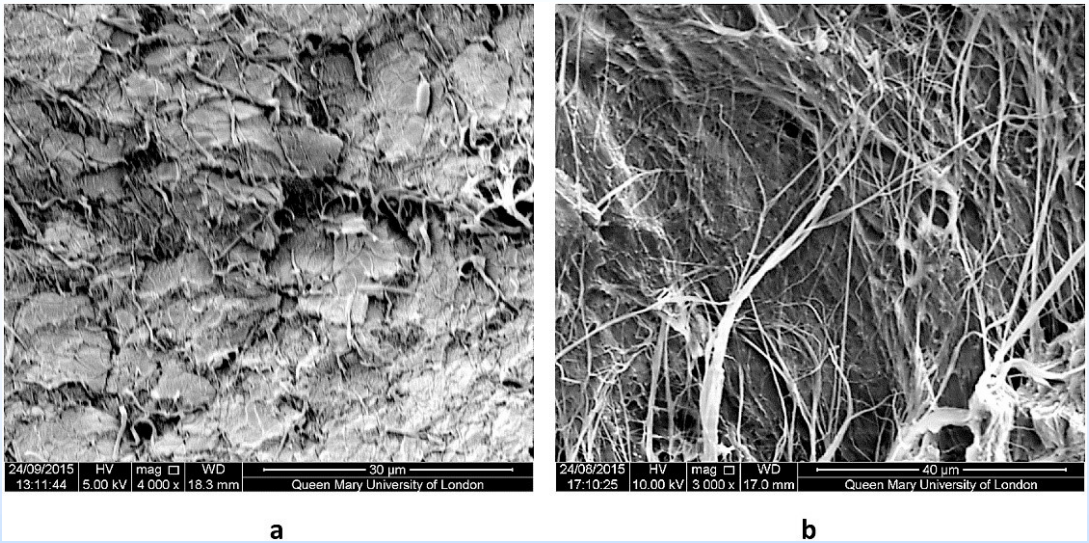
PLA
EastONE
CoPET



https://www.slideshare.net/rdhurdle/3-2010-winged-fiber-presentation

„Ostrovy v moři“ bikomponentní vlákna

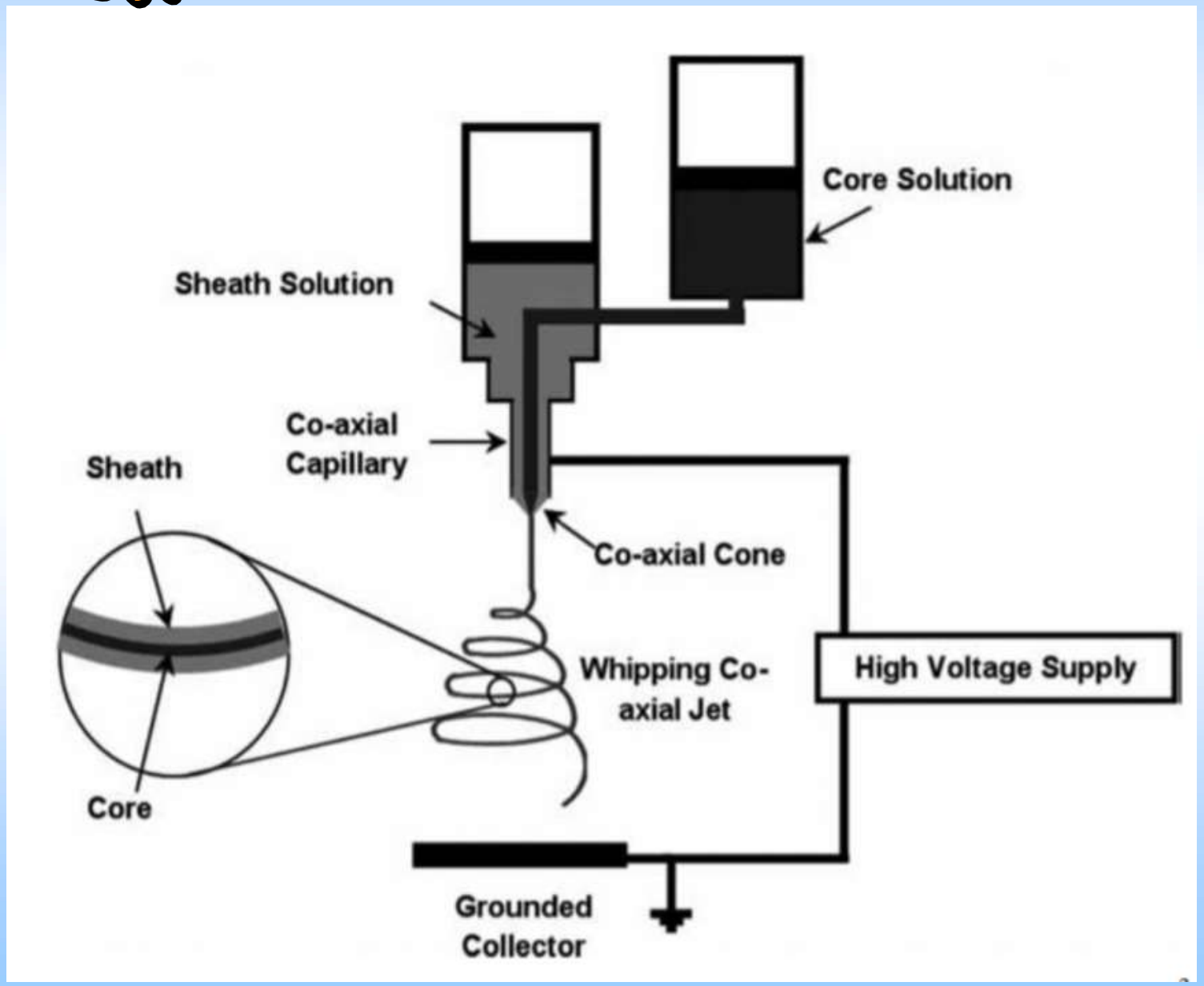




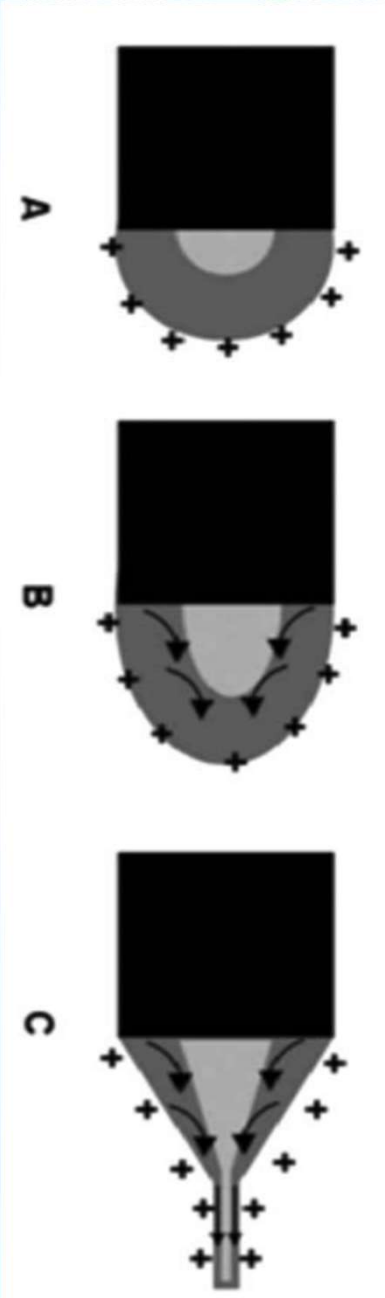
EM images of cold fractured cross-sections of: (a) as-extruded PTFE/PVA fibre (19 vol% PTFE), and (b) post-drawn PTFE/PVA fibre

https://www.sciencedirect.com/science/article/pii/S0032386116311442

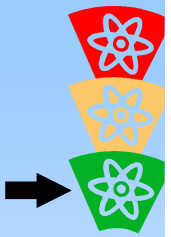
Bikomponentní nanovlákna



Fáze tvorby Taylorova kužele u elektrického zvlákňování



https://onlinelibrary.wiley.com/doi/pdf/10.1002/app.46265



Analysis of fibre mixtures

Toxicity of chemicals used

Acetone - flammable, irritant, skin drying, LD50, oral, rat(mg.kg-1): 5800 mg/kg

Chlorate - corrosive, oxidising, highly toxic to aquatic organisms when acidified with Cl2, LD50, oral, rat(mg.kg-1): 1100

Zinc chloride - Harmful if swallowed.Causes burning.Highly toxic to aquatic organisms, LD50, oral, rat(mg.kg-1): 350

Formic acid - Corrosive, toxic, flammable

Benzyl alcohol - LD50, oral, rat (mg.kg-1): 1,230

Dichloromethane - Suspected of causing cancer, LD50, oral, rat (mg.kg-1): 1 600

Sulphuric acid, 75 % w/w - corrosive

Dimethylformamide - Flammable liquid and vapor. May harm the fetus in the mother's body. Harmful in contact with skin. Harmful by inhalation. Causes severe eye irritation, Carcinogenicity: May form nitrosamines under certain conditions. Nitrosamines have been shown to be carcinogens in animal tests, LD50, oral: rat = 2200 mg/kg.

Carbon disulfide - highly flammable liquid and vapour. Skin irritant. Causes severe irritation to the eyes. Suspected of impairing reproductive capacity. Suspected of damaging the fetus in the mother's body. Causes damage to organs with prolonged or repeated exposure. LD50, oral, rat (mg.kg-1): 3 188

Anhydrous (glacial) acetic acid - corrosive

Cyclohexanone - Harmful by ingestion, skin contact and inhalation. Irritating to skin. Causes serious eye damage. LD50, oral, rat (mg.kg-1): 1890

Xylene - Flammable liquid and vapour. May cause death if swallowed and enters the respiratory tract. Irritating to skin. Causes severe eye irritation. May cause respiratory irritation. May cause organ damage by prolonged or repeated exposure. Harmful in contact with skin or by inhalation, LD50, oral,

Technical standards

A technical standard is a regulation that establishes technical requirements or technical solutions for repeated actions and processes. The technical standard specifies the exact procedure of the test to be carried out or defines the technical terms used.

With a little exaggeration, it can be said that what cannot be measured properly must be standardised. The main objective of standards (or standardisation) is to understand and define. A technical standard is actually a documented agreement.

The use of standardised procedures is in principle voluntary. Some standards have been made binding by law, e.g. some standards defining e.g. occupational safety and health.

System of technical standards applicable in the Czech Republic

1. ISO - international standards that summarize test methods, markings and terminology

2. EN - European standards that summarise test methods, marking, terminology and product safety

3. CSN - Czech (formerly Czechoslovak) standards, national validity.
In technical practice, national standards of other countries can also be encountered:
DIN (SRN), GOST (Russia), BS (GB), ASA (USA), ASTM (USA).

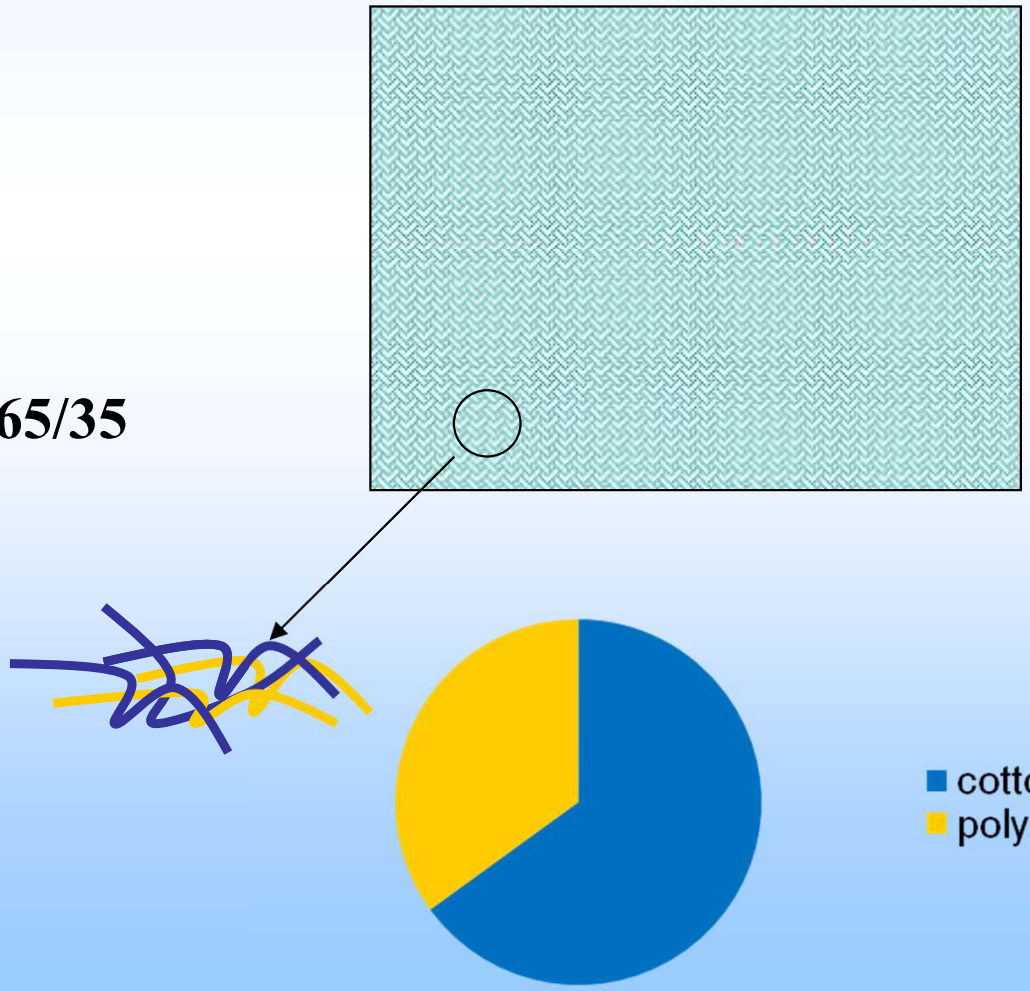
Common cloths (textiles)

Textiles fibers are used typically as blends

1 textile=more fibers

Typically 2 compounds
Up to 4 -5 different fibers

for example: cotton polyester 65/35
65 % cotton
35 % polyester



Quantitative fiber analyses – problem of sample humidity

The fibers change its weight according the relative humidity of air

<u>Ratio of fibers at standard conditions !!!</u>

Standard condition (for business, laboratory…): 65% RH, 20°C

Difference to absolute dry fibers:

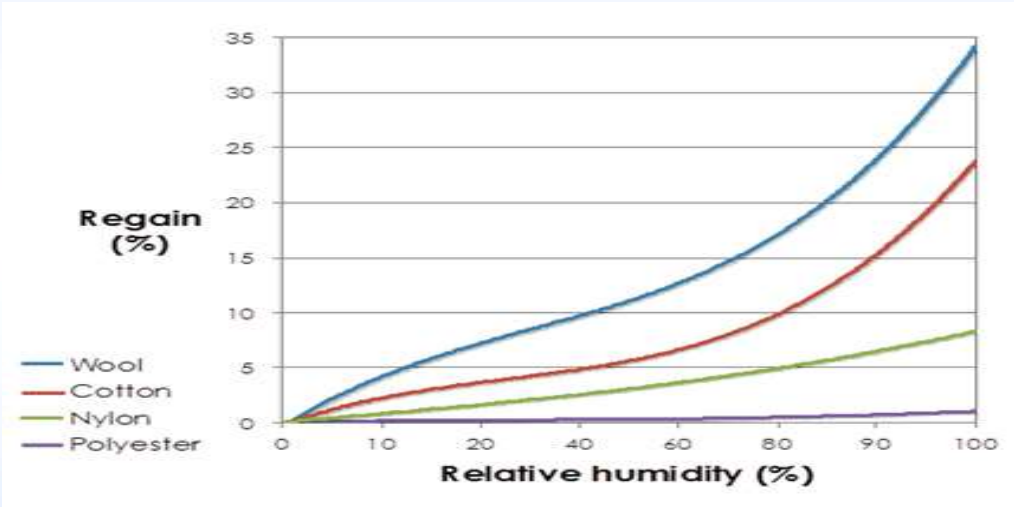
Polypropylene +0.1%

Polyester +0.7%

Polyamide +4%

Cotton +7%

Wool +18%



Natural fibers = problem of humidity

Different humidity – different ratio of components in a blend

Sample: absolute dry polypropylene/ wool 40/60

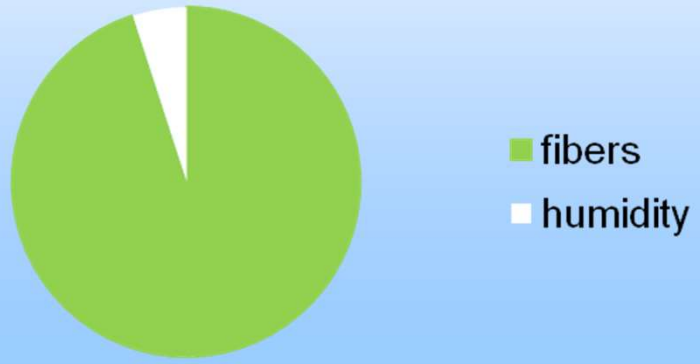
At standard conditions: ???

40x1/(40x1+60x1.18)=40/111=36%

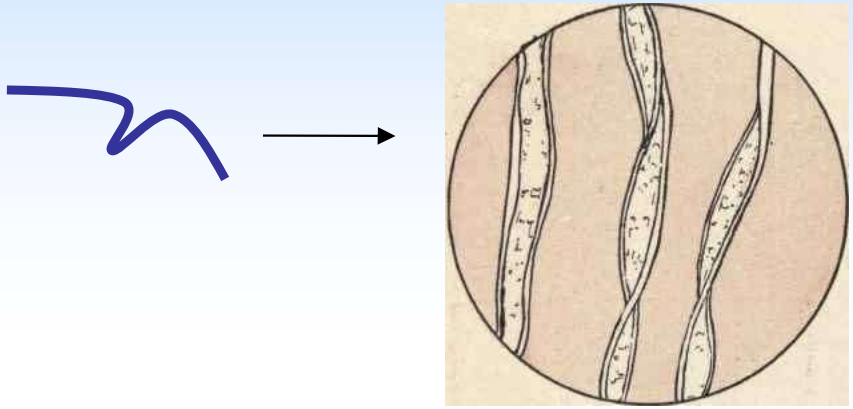
60x1.18/(40x1+60x1.18)=71/111=64% 36%+64%=100%

Quantitative fiber analyses – problem of sample humidity

- Water absorbed in fibers influences the results of quantitative analyses.
- Each fiber absorbs different quantity of water according its chemical composition. The quantity of absorbed water is connected with their humidity.
- Higher air humidity = high contain of water in fibers
- Solving: before the analyses is necessary remove the water from fibers by drying at 105 °C – time is unlimited, we have to wait to stabilized weight, ideal dried (absolute dry) sample has the weight M1



Qualitative analyses – fiber identification



First step = fiber identification

Is it a mixture?

What kind of fibers is inside?

Special fibers (=special problems)
- glass fibers, basalt fibers, aramides...
- nobody has the useful methods
- to stable for standard decomposition methods

Quantitative fiber analyses – problem with impurities

Possible problems:

- **Additives (pigments from prints …)**
- **Finishing (hydrophobic treatment, flame retardants …)**
- **Preparations**

Solving: Washing out of all impurities (or extraction in organic solvents)

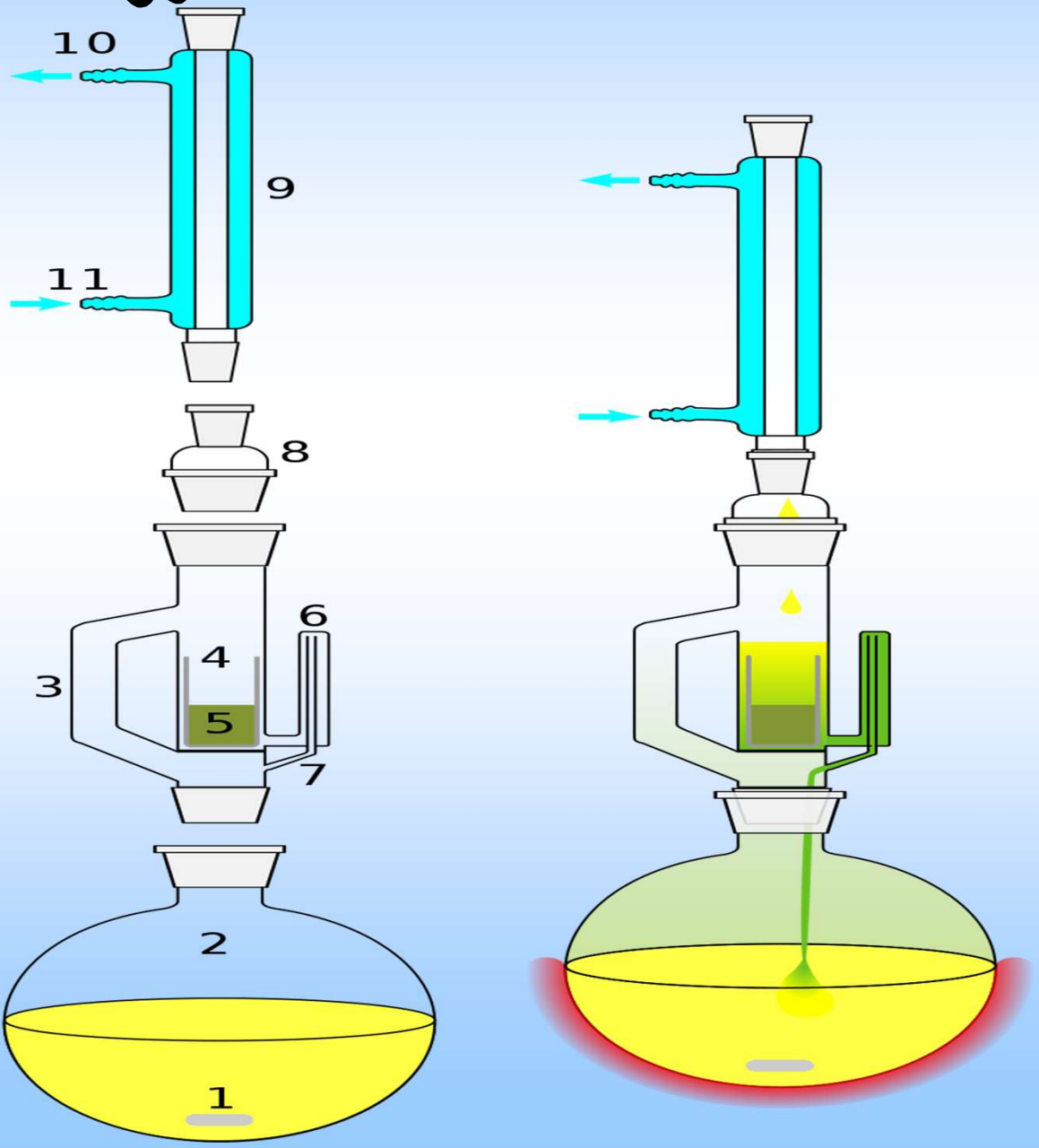
The behavior of these impurities in solvent is unknown – will be soluble completely, partially ... ?

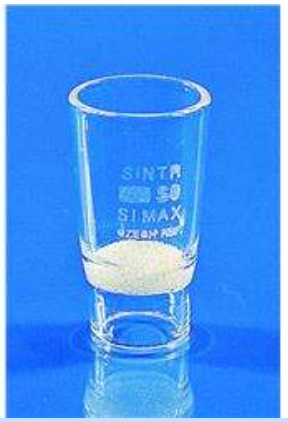
Impurities (especially final treatments) can reduce the affect of solvent to textile – fibers are protected, the wetability is low...

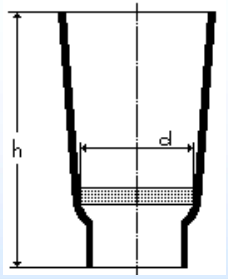
Preparations we should remove before the analyses – typically by organic solvent – application of nonpolar solvent in many cycles (mixture of petrolether and ethylether in ration 1:1)

Other kinds of impurities is necessary to remove by other method – enzymatic desizing, or washing in water ....

Soxhlet extractor + filtration







Frita - filtration

pores	description
150-250 µm	S0
90-160 µm	S1
40-90 µm	S2
15-40 µm	S3
5-15 µm	S4

Samples for analysis

Sampling and analysis should be carefully documented, preferably in a detailed laboratory logbook (or analysis book). A proper record should include answers to the questions Who?, Where?, What?, When?, How many times?, According to what?, How?, What was the result?

A carefully kept laboratory logbook is useful for tracing back information, e.g. on variations in the properties of raw materials, products, etc.

In laboratories, input tests of raw materials, intermediate control and output tests of products are often carried out. This information allows to ensure stable production quality and to identify sources of problems.

The transfer of raw materials, semi-finished products and products in industry is based on agreements between suppliers and customers, who define by mutual agreement the characteristics of the material to be transferred. In general, the supplier tries to have loose standards and the buyer tries to tighten the standards.

Samples for analysis

Samples for analysis should be taken so that they are averaged and defined (!).

For example, when taking wool fibres from a bale, samples should be taken not only from the surface of the bale but also from deeper parts of the bale.

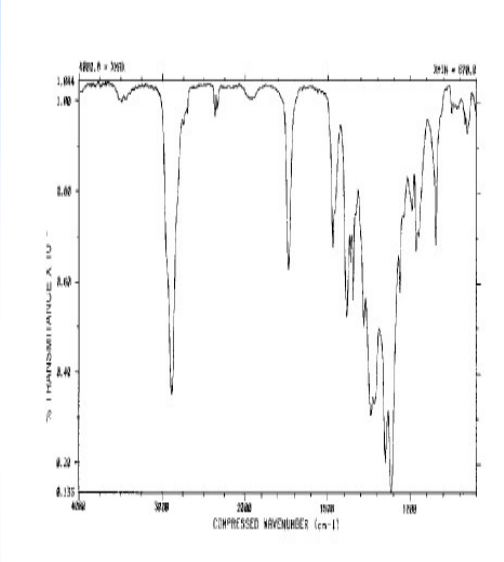
When checking the yardage, the beginning of the middle and the end of the lot should be observed. In general, the edge and centre of the fabric (in the direction of the weft) may also vary.

For textile processing aids (TPPs), it is often necessary to homogenize the chemical throughout the container. This is a very complicated operation when removing, for example, fatty substances. For reasons of a deeper understanding of the processes involved, e.g. separate layers in the container can also be tested.

Quantitative fiber analyses – possibility methods

Quantitative analyses:

- <u>Instrumental methods such as IR spectroscopy</u>
special applications, short time results, low accuracy



- <u>Destructive weight analyze methods</u>
standard technique, robust, long time experiments

Quantitative fiber analyses

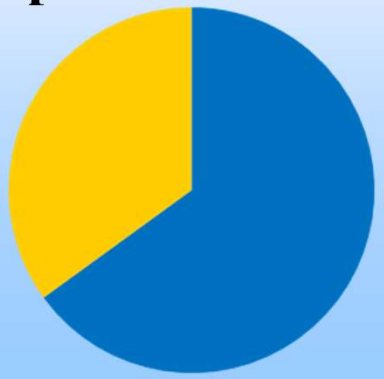
Destructive weight analyze methods

<u>Basic idea:</u> I remove only one component from the fiber blend, fiber rest will contain other kinds of fibers. The weight of these fibers is the same as in original sample.

The weight of original sample we know – we can calculate the contain of the removed fibers in the original sample.

So we can continue with all other fibers. The sum of all fibers in one textile is 100%.

For analyses is recommended to cut sample to small peaces (approximately 10x10mm) Smaller samples are more sensitive to used solvents – the structure is more open and stirring can be more effective



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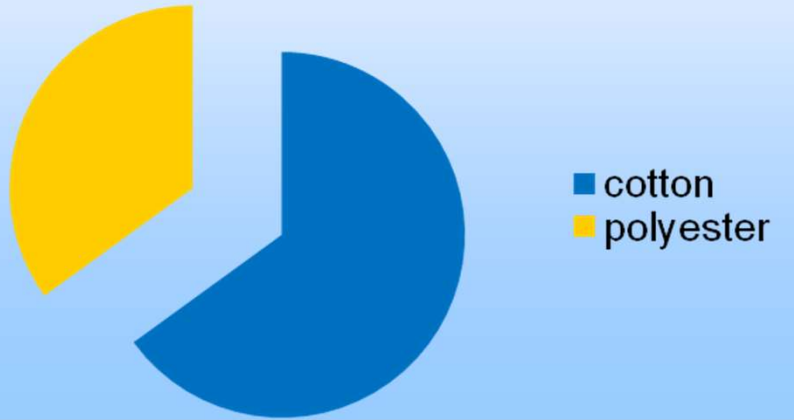
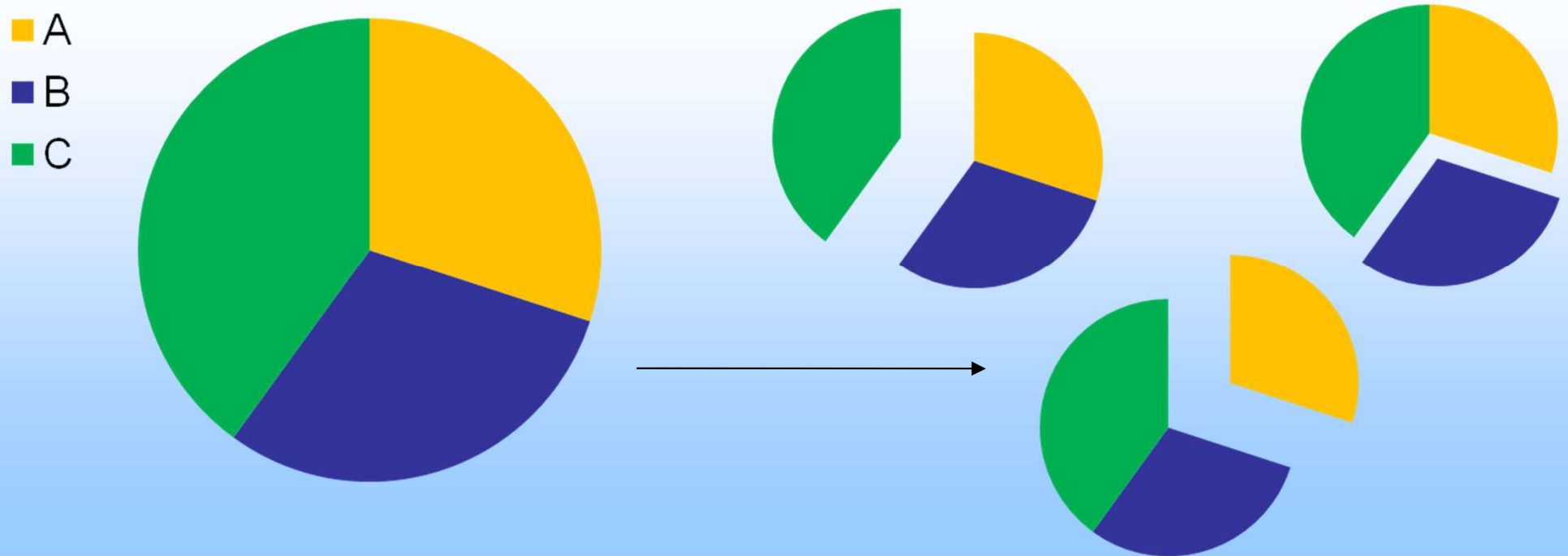


Quantitative fiber analyses

All times we are using methods, with remove only one kind of fibers from the textile.
Mixture of 3 (or more) components:
Is necessary to use 2 (or more) methods, one method for dissolving of one fiber
For every test is necessary to use new sample. Using of before used (attacked) fibers is prohibited – used fibers are more sensitive to new solvent.



Quantitative fiber analyses - organization

Standard recipe:

1) **qualitative analyses of fibers (aim: is it a blend? Find the right method of qualitative analyses)**
2) **preparation of tree parallel samples, 2g each**
3) **cleaning of samples - extraction**
4) **cutting of samples to small peaces**
5) **drying (105°C) of samples to constant weight M1**
6) **dissolving of „more soluble“ component of blend according the technical standard**
7) **the rest of insoluble fibers separate quantitatively from the solution on the filter glass**
8) **wash out the insoluble of solvent from the residual fibers**
9) **drying of insoluble fibers up to constant weight M2**
10) **calculation of the ratio of both components in this blend in the case of absolute dry samples**
11) **calculation of the ratio of both components in this blend in the case of standard air-conditioned samples**

Methods for quantitative fiber analyses

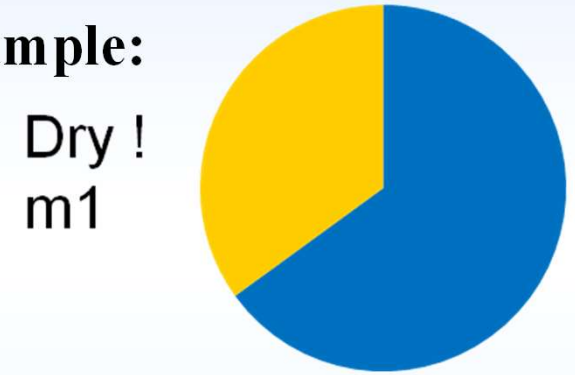
Fiber blend		method	
soluble	insoluble	chemicals	condition
cotton, polyamide, viscose	Polyester, acrylic, polypropylene, wool	H2SO4 75%	50°C, 1 hour
acetate	Other fibers	acetone	20°C, 1 hour
acrylic, polyvinylchloride, acetate	Other fibers	DMF	95°C, 1 hour
polyamide, acetate	Other fibers	HCOOH 85%	20°C, 15 min
wool, silk	Other fibers	NaClO (35g active Cl/litre) + 5g/l NaOH	20°C, 40 min
polyvinylchloride	Other fibers	cyklohexanon	Boiling temperature, 60 min

Calculation of fiber ratio (dry)

calculation of the ratio of both components in this blend in the case of absolute dry samples:

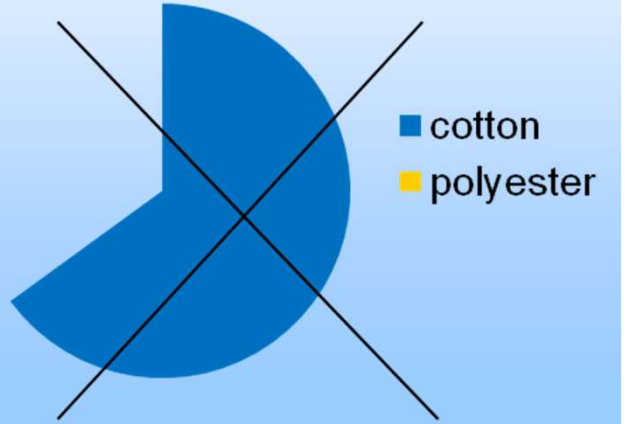
Ratio of dissolved fibers (a1) in % in absolute dry sample:

$$a_1 = \frac{(m_1 - m_2.K).100}{m_1}$$



Ratio of insoluble fibers (a_2) in % in absolute dry sample:

$$a_2 = \frac{(m_2.K).100}{m_1}$$



m_1 weight of all fibers together in g,
m_2 weight of insoluble fibers v g,

Correction factor K

K ... correction factor, „insoluble“ fibers are sometimes „low soluble“ in the used solvent, factor is in technical standard

The methods are selected so, that the factor is typically 1.

Ideal K=1:

One kind of fibers is total dissolved

The other component is not attacked

Ratio of air-conditioned fibers

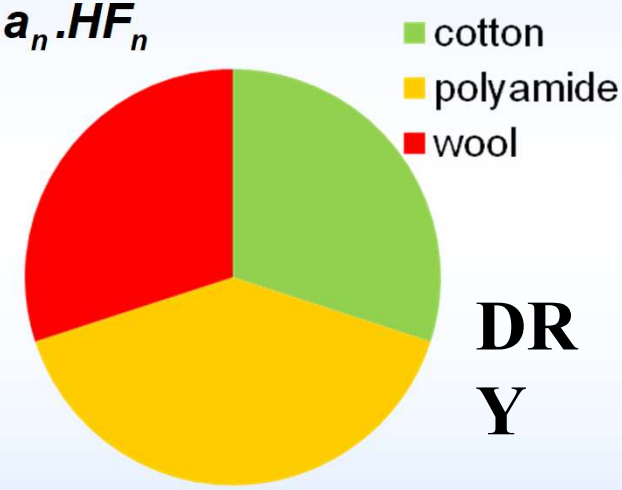
calculation of the ratio of both components in this blend in the case of standard air-conditioned samples (65% air relative humidity, 20°C):

$$X_1 = \frac{a_1.HF_1}{a_1.HF_1 + a_2.HF_2 + \ldots + a_n.HF_n} \qquad X_2 = \frac{a_2.HF_2}{a_1.HF_1 + a_2.FV_2 + \ldots + a_n.HF_n}$$

X_1 … weight ratio of fibers 1 in analyzed textile at standard conditions

X_2 … weight ratio of fibers 2 in analyzed textile at standard conditions

fiber	Humidity of fiber (HF)
Wool	1.180
Viscose	1.110
Polyamide	1.045
Cotton	1.085
Acetate	1.060
polyvinylchloride	1.010
acrylics	1.010
polyester	1.007
polypropylene	1.001



DRY

WE

Real sample

Real sample:

Mixture cotton/polyester (estimated by microscopy and qualitative fiber analyses)

Weigh of air dry sample is 2.458 g (high precision is necessary)

After drying at 105°C we have: M1=2.327 g

The humidity in textile was: H=(2.458-2.327)/(2.458)=5,32%

(it is a redundant calculation – we don't know the humidity of air and the real property of fibers, damaged fibers or fibers after chemical modification can have different standard humidity)

Samples we will cat to small peaces – to intensify the solution

Real sample

Real sample:

In the mixture cotton/polyester is more sensitive to solvents cotton – we will use the solvent for cotton 75% H_2SO_4

We will heat the 75% H_2SO_4 up the 50°C in a thermostatic bath

We will put in our cuted sample

We will wait for 1 hour, during this time we will mix this reaction mixture well

The separation of insoluble fibers on filter glass (=sintered glass filter, =sintered glass), the absolute dry weight of filter glass is 15.456g

Rinsing of insoluble fibers on the filter glass with solution of

Real sample

Real sample:

Calculation of insoluble fibers weight (absolute dry) M2= 1.333g

Calculation of ratio between absolute dry components:

Cotton: a1= (2.327-1.333x1)/2,327 =42.7%

Polyester: a2= (1.333x1)/2,327 = 57.3%

a1+a2=100%

Prediction of ration of cotton and polyester as standard air-conditioned samples (65% air relative humidity, 20°C):

Cotton: a1= (2.327-1.333x1.007)/2,327 = %


Děkuji za
pozornost