The development of an innovative pH-sensor based on colour changing textiles

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Research about pH-sensitive textiles is necessary

Colour change textiles

unwanted → usable as sensors

Colour change

immediately visible → first signal or warning

Advantages of textiles

flexible, covering big surfaces, local signal

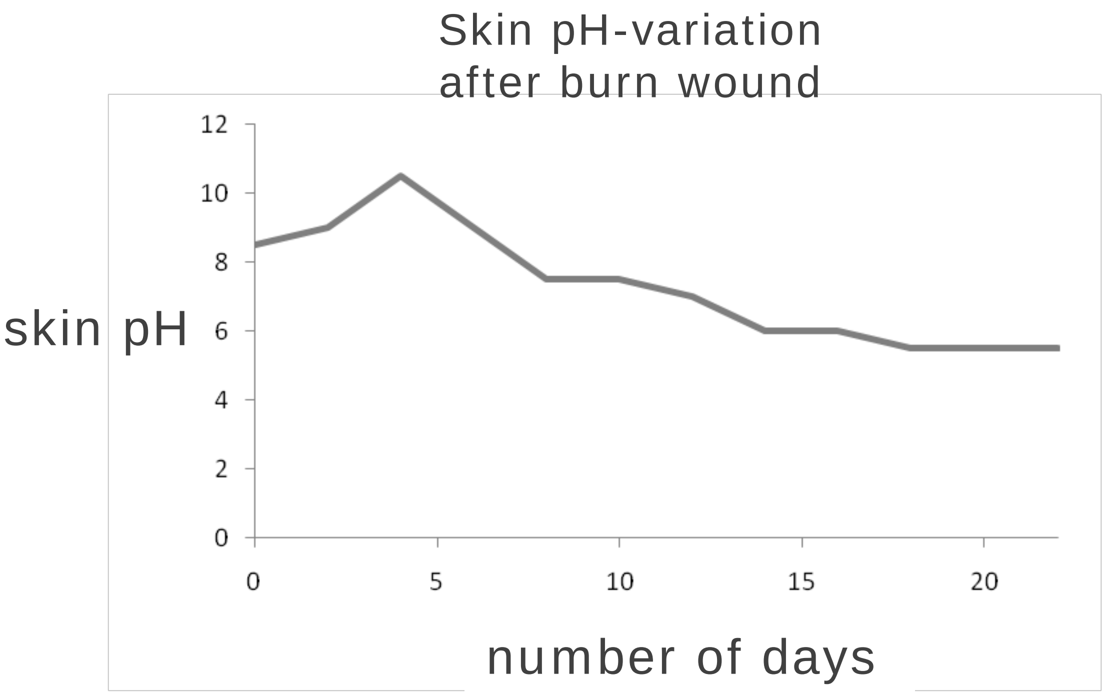
pH

important parameter in diverse circumstances

Research about pH-sensitive textiles

still preliminary

pH-sensitive textiles have various applications



Wound bandage

follow-up of healing process

Protective clothing

indicator of acid vapours

Geotextiles

indicator of optimal pH
for growth

pH-sensitive textile materials

Broad screening on conventional textiles

Dye Brilliant Yellow

Dye Alizarin

Broad screening on nanofibrous textiles

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Broad screening on conventional textiles

A set of 10 pH-indicators was applied,

by a standard dyeing process, on

- cotton
- nylon 6
- nylon 6.6

Two characteristics were analyzed

- dyeing performances (levelness, colour depth and exhaustion)
- halochromic properties (colour shift between pH 2-11)

Results of broad screening show feasibility

	Cotton	*Nylon 6*	*Nylon 6.6*
Congo Red	√	√	√
Methyl Orange		√	√
Methyl Red			
Chlorophenol Red			
Bromocresol Purple		√	√
Alizarin		√	√
Nitrazine Yellow		√	√
Bromothymol Blue		√	√
Brilliant Yellow	√	√	√
Phenol Red			

√ = good dyeing performances

= halochromic sensitivity

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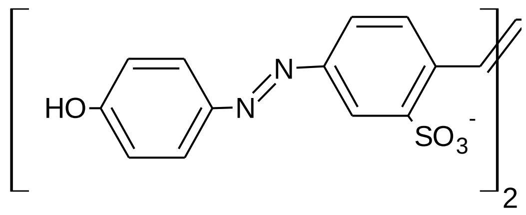
Broad screening on electrospun textiles

Dyeing process of Brilliant Yellow on cotton is optimized

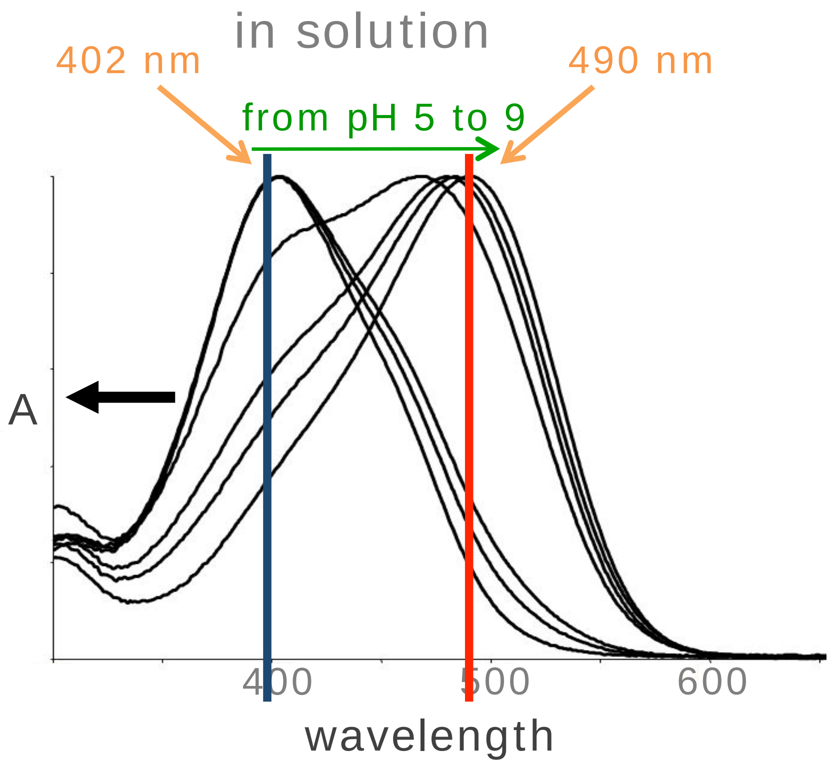


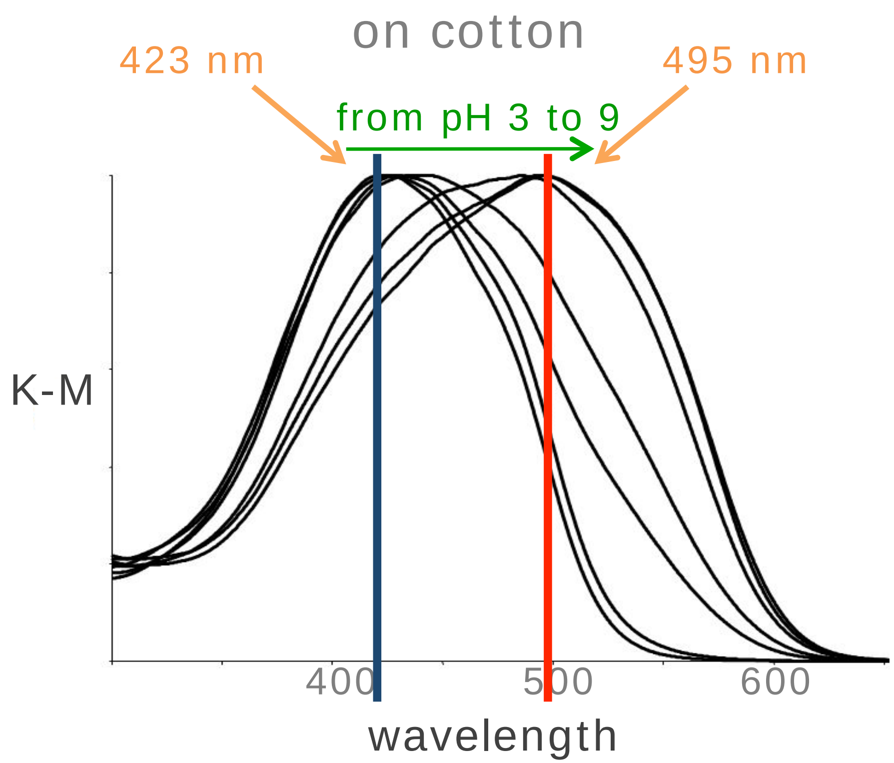
- Brilliant Yellow
  - anionic diazo dye
  - used as pH-indicator in solution (pH 6.5-8.0)
- Optimization of dyeing process
  - exhaustion of 91%
  - after treatment with Perfixan: improved water fastness

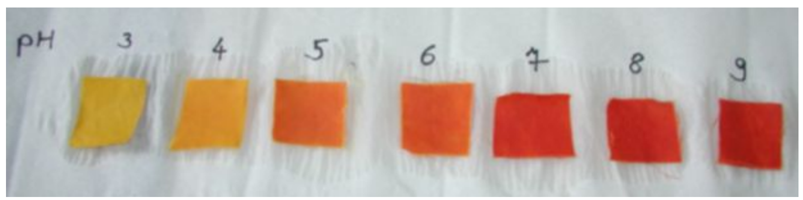
Water fastness	*Adjacent cotton*	*Adjacent wool*
Without treatment	2	3/4
With Perfixan treatment	4	5

UV/Vis spectra show different behaviour of Brilliant Yellow in solution/on cotton

UV-Vis spectra Brilliant Yellow with pH-variation



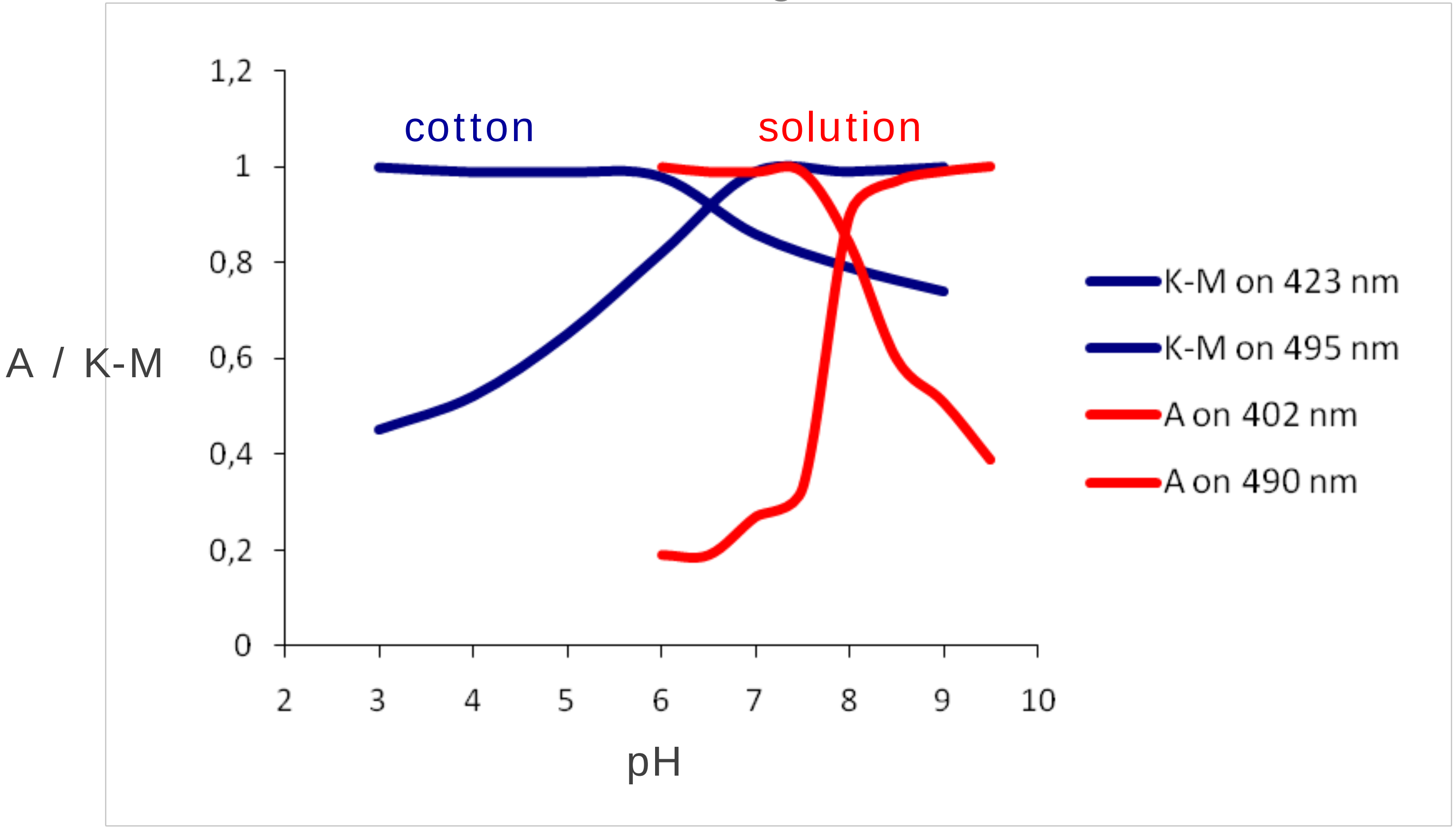




UV/Vis spectra show different behaviour of Brilliant Yellow in solution/on cotton

Immobilizing Brilliant Yellow on cotton

- broadening of pH-range of colour change
- shift in maximum wavelengths



Raman spectra confirm the different behaviour

Solution

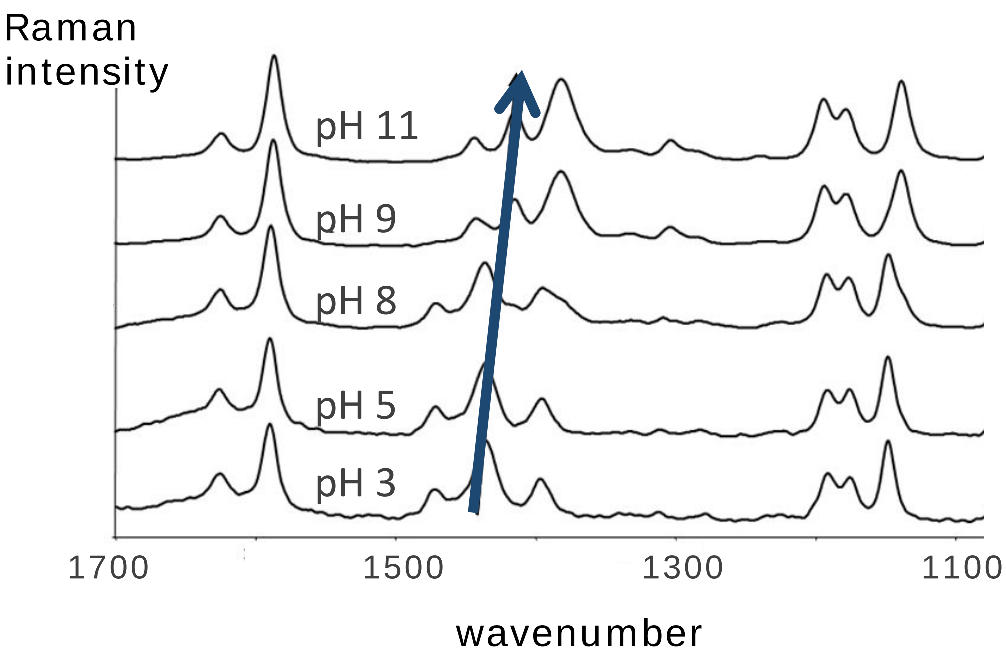
shift of peaks in region 1300 – 1500 cm^{-1}

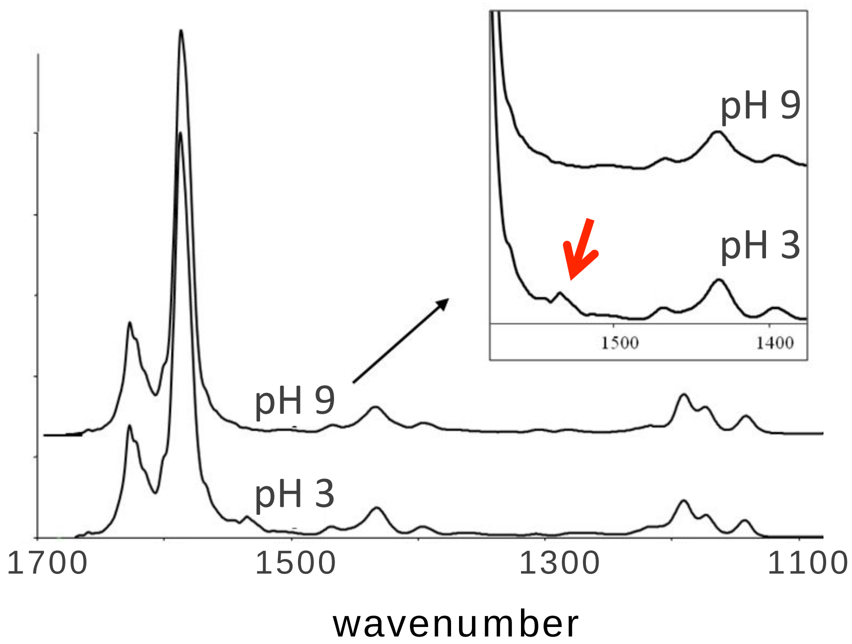
no peak at 1530 cm^{-1} in acid pH

Cotton

no shift of peaks in region 1300 – 1500 cm^{-1}

peak at 1530 cm^{-1} in acid pH



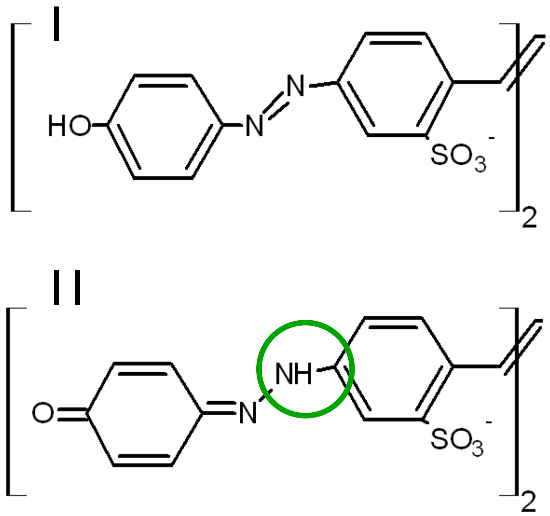


Differences in molecular structure explain differences in behaviour

Molecular structure of Brilliant Yellow in acid environment

solution

cotton



In an aqueous solution

only I

On cotton

combination of I and II

⟶ peak at 1530 cm^{-1} due to CNH-bending

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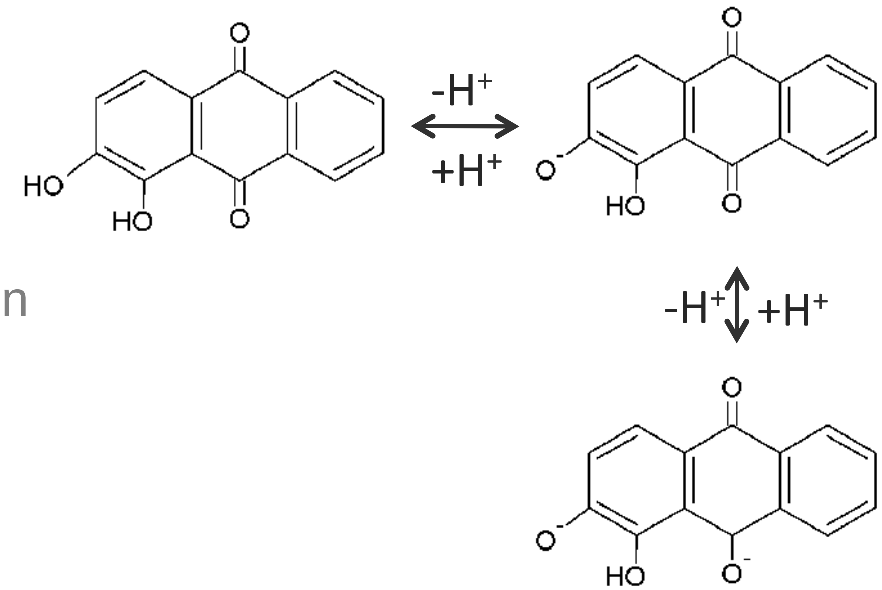
Dyeing process of Alizarin



Alizarin

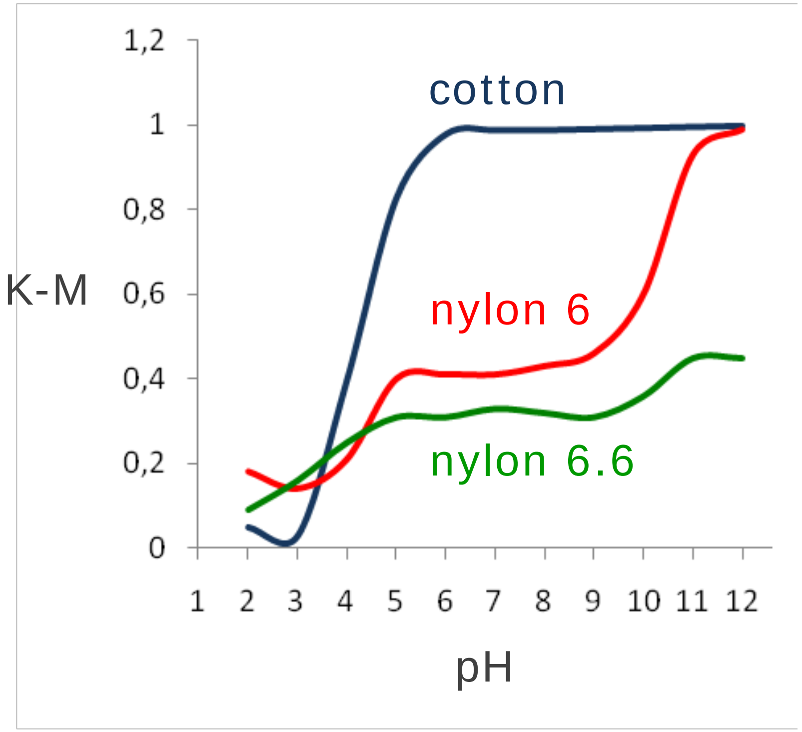
- anthraquinone dye
- used as pH-indicator in solution
- (pH 5.8-7.2 and 11.0-13.0)

Optimization of dyeing process

- cotton: 20% exhaustion and low water fastness
- nylon 6 and 6.6: 99% exhaustion and low water fastness

Fabrics show clear colour change with change in pH

Alizarin shows different behaviour dependant on the fibre type



Cotton
single colour change

Nylon 6
double colour change

Nylon 6.6
single colour change

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Halochromic nanofibres can offer new possibilities

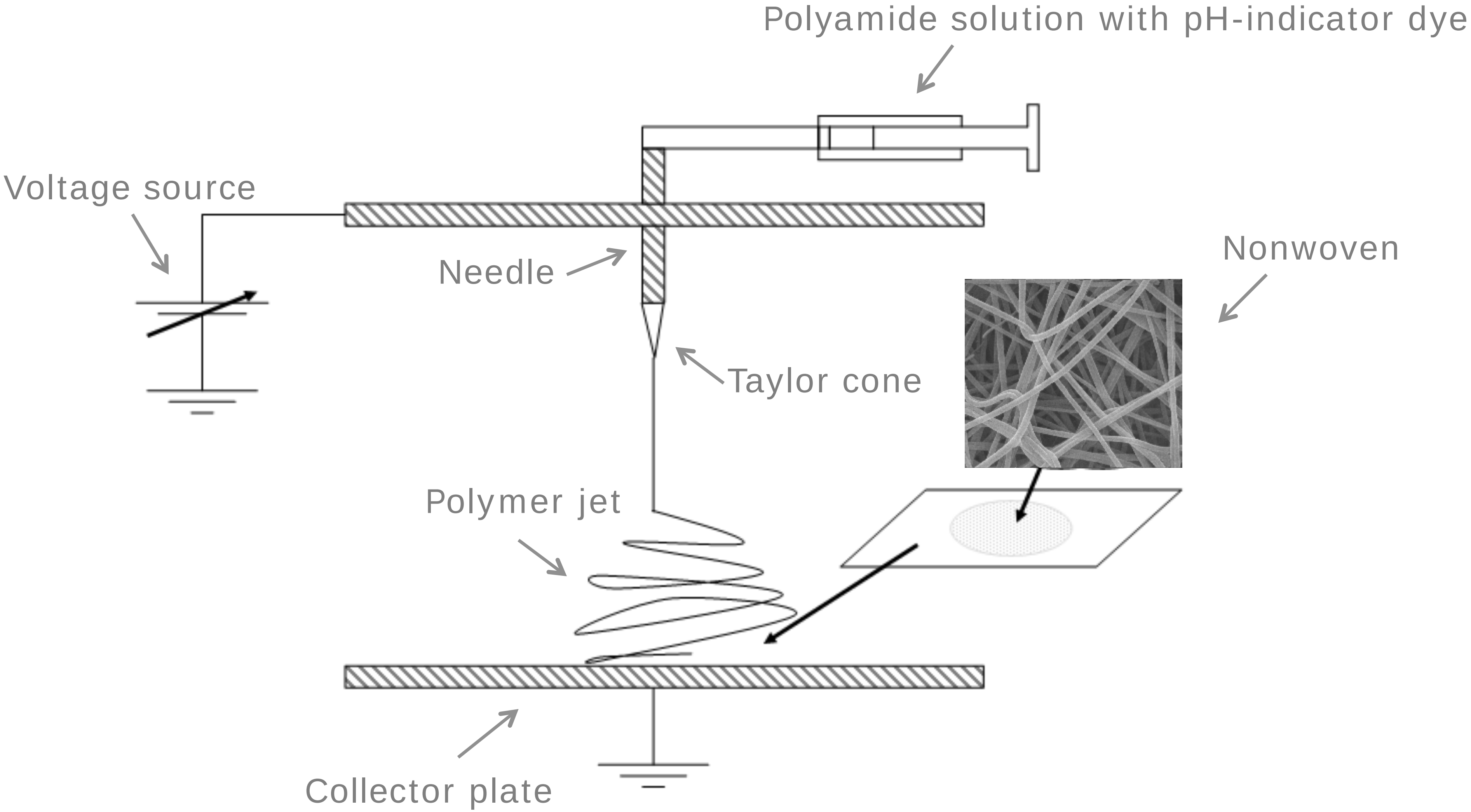
Unique characteristics of nanofibrous nonwovens

- high specific surface area
- small pore size
- high porosity

Suitable for specific applications

- wound dressings
- filtration

Electrospinning is a powerful technique to produce nanofibres

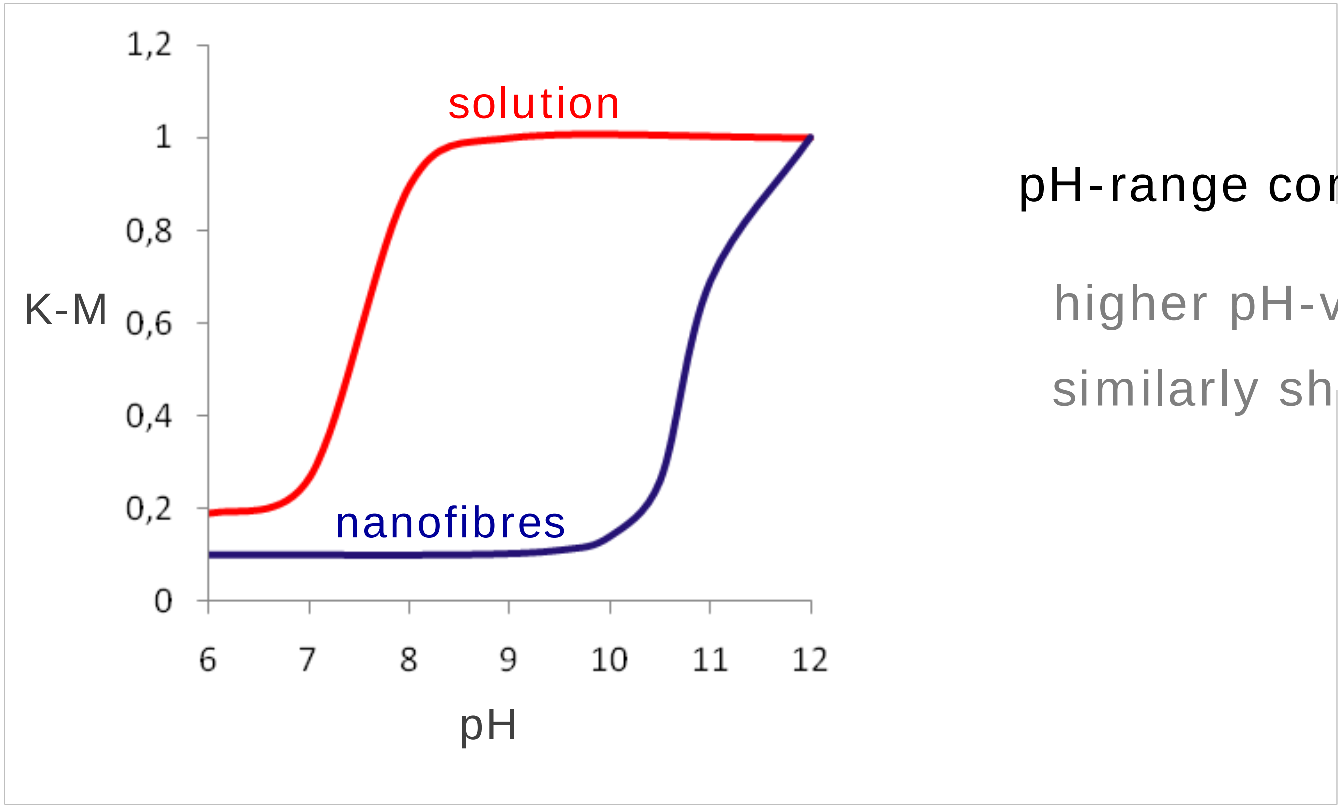


Adding pH-indicators has no influence on the average nanofibre diameter

pH-indicator	*Average diameter*	*Standard deviation*
Chlorophenol Red	169	24
Bromocresol Purple	140	30
Nitrazine Yellow	173	36
Bromothymol Blue	198	42
Brilliant Yellow	165	24

% omf Brilliant Yellow	*Average diameter*	*Standard deviation*
0.08	177	23
0.16	180	18
0.32	166	24
0.54	178	27
1.35	183	20

Brilliant yellow shows different behaviour in polyamide nanofibres and in solution



pH-range compared to solution

higher pH-values

similarly sharp transition

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It is possible to develop a textile pH-sensor using pH-indicator dyes

pH-indicator dyes were successfully applied on conventional textiles

pH-indicator dyes were successfully incorporated in electrospun nanofibres

The dye behaviour is dependant on the surrounding environment

- pH-range
- maximum wavelengths
- molecular structures

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