The search for superior cotton fibres of the future: Novel small scale tests needed today

MSc. Özgür Ceylan
prof. dr. ir. Karen De Clerck

Ghent University - Belgium
Department of Textiles

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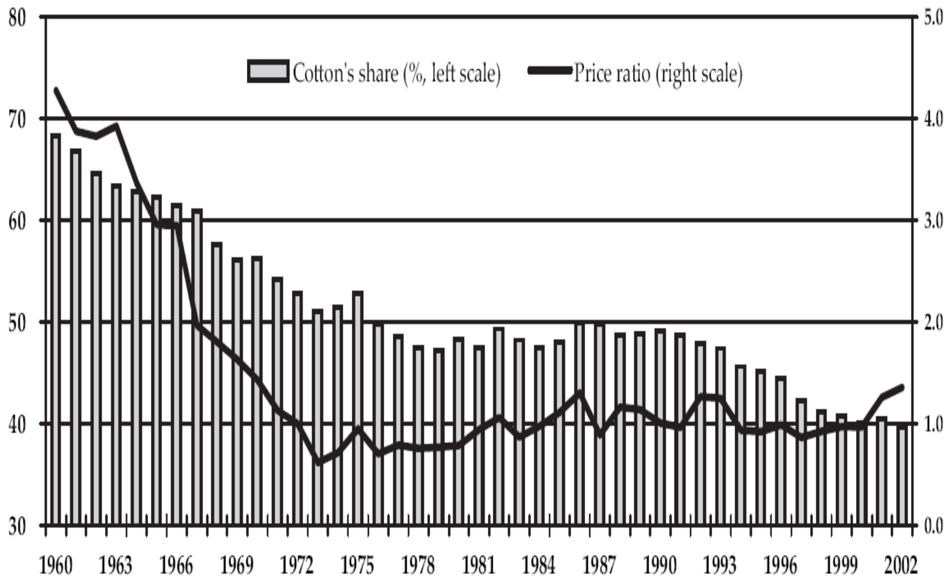
Cotton is an important cash crop in many developing economies

- Main merchandize export
  - up to 40 % - more than 5 % of GDP
- Important contributor to rural livelihoods
  - 100 million rural households
- Sustainable material
  - carbon and energy positive
- Good fibre characteristics
  - water absorption, light weight, biodegradability ...

Cotton production suffers from the increased competition of synthetic fibres



Source: ICAC (2003).

Intensive R&D synthetic fibres

- tuneable fibres
- reduction in costs
- new uses
- quality improvements
- (similar to cotton properties)

Increased fibre demand

- same rate as population

To remain competitive cotton fibre quality must be improved

- Chemical treatments
  - extra processes, costly, unsustainable
- Plant breeding
  - limitations in compatibility availability of traits
- Bioengineering
  - possibility of transferring foreign genes
    - fibre quality modification
    - stress tolerance
    - fungus resistance

New bioengineering approach is to produce cotton for high value added applications

Altered Reactivity

efficient dyeing process

- improved fastness properties
- decreased dyeing time and waste water

improved reactivity with reactants

- flame retardants
- anti-crease agents
- softeners etc...

Flame retardant cotton

inherent flame retardancy

New test methods applicable on a few grams of material should be developed

Reactivity

- A semi industrial dyeing method
- C.I. Acid Orange 7 method

Flame Retardancy

- Thermo gravimetric analysis (TGA)
- Cone Test

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A small scale dyeing method was developed for indirect evaluation of reactivity

Dyeing of Fibres

- allows dyeing of amounts less than 100 mg

Spectroscopy measurements

- a dedicated sample holder was used
- calculation of colour coordinates (L*, a*, b*)
- optimisation of sample amount for spectroscopy

Statistical Analysis

- one way ANOVA

Screening tests for bioengineered lines

- 1st phase lines

Sample amount has no correlated effect on spectroscopy measurements

A standard direct dyeing process

Sample amount	*Mean ΔE*	*Standard Dev.*
100 mg sample	33.80	.86
50 mg sample	33.88	.72
30 mg sample	34.40	.99
20 mg sample	34.82	.41

9 replicates for each sample

The reproducibility of dyeing experiments is good (.05 significance level)

A standard direct dyeing process

	Mean ΔE	*Standard Deviation*	*F*	*Significance*
Sample 1	18.58	.72	1.70	.20
Sample 2	18.52	.49		
Sample 3	17.97	.54		
Sample 4	18.83	.70		

5 replicates for each sample

Reactivity of first phase bioengineered line is slightly higher than reference lines

A standard reactive dyeing process

Cotton Lines	Δ E (1st Dyeing)	Standard Deviation	Δ E (2nd Dyeing)	Standard Deviation
Reference	53,17	,41	53,75	,34
Control line	51,32	,31	52,27	,46
Line 1	54,72	,29	54,16	,58

3 replicates for each dyeing / 5 replicates for spectroscopy measurements

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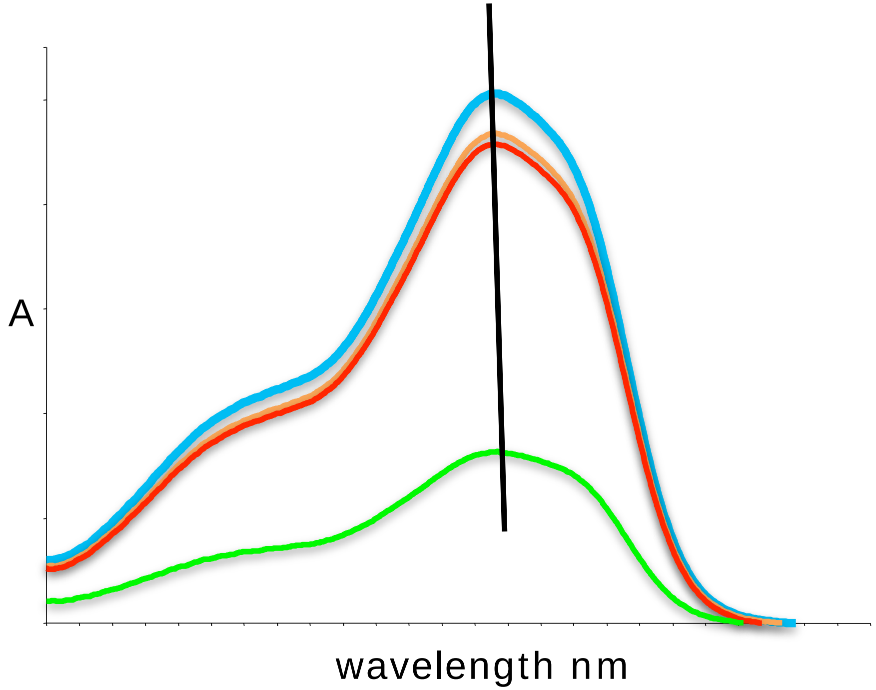
C.I. Acid Orange 7 is a spectrophotometric method used for detection of amino groups

- Feasibility study
  - using cationic yarn as a positive control
- Optimisation
  - time of dyeing
- Screening tests for bioengineered lines
  - 2nd phase lines

C.I. Acid Orange 7 is a sensitive method for the determination of cationic groups

	Absorbance at 484 nm	*Standard Dev.*
Stock solution	0.50	.005
Cotton fibre	0.46	.002
Reference yarn	0.45	.004
Cationic yarn	0.16	.005

2 replicates for each sample

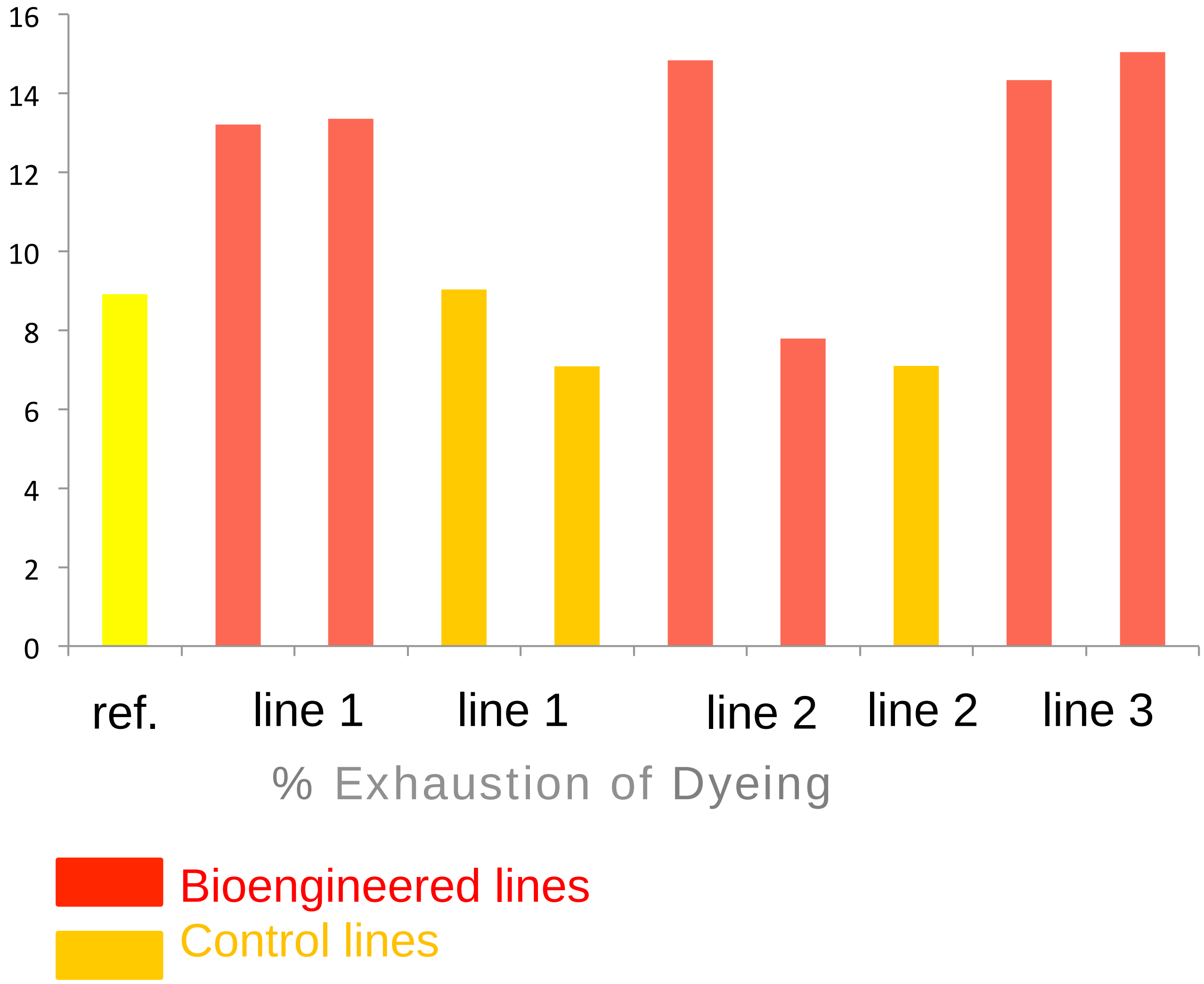


Dyeing time has a minor effect on the value of maximum absorbance

	Absorbance at 484 nm (1 hour)	*Std. Dev.*	*Absorbance at 484 nm (2 hours)*	*Std. Dev.*	*Absorbance at 484 nm (3 hours)*	*Std. Dev.*
stock solution	--	--	--	--	0.498	.0003
reference yarn	0.463	.005	0.462	.0006	0.464	.007
cationic yarn	0.194	.0002	0.193	.0008	0.191	.002

2 replicates for each sample

Reactivity of trangenic lines is higher than reference fibres



Dyeing with

Acid Orange 7

Test methods applicable on a few grams of material

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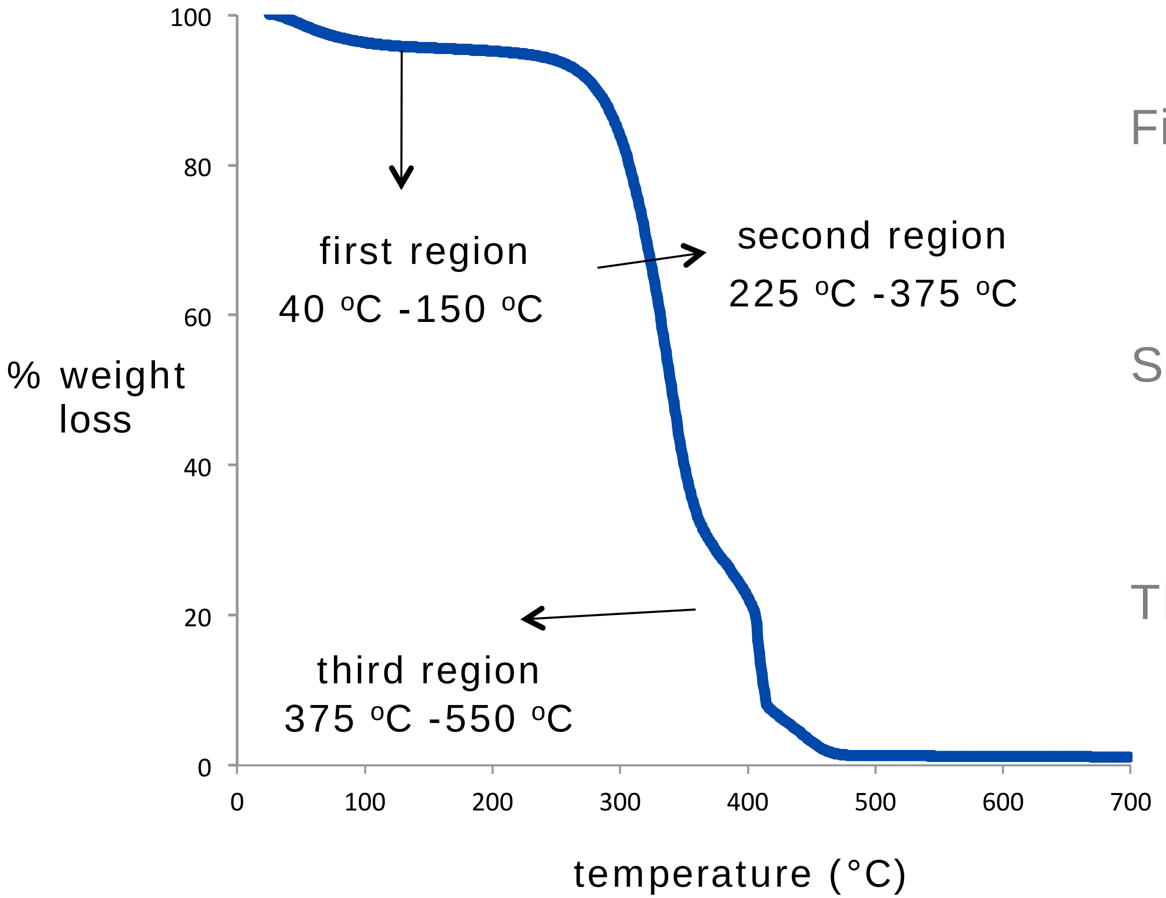
Three main major weight loss regions were observed on thermograms of fibres



First region

moisture

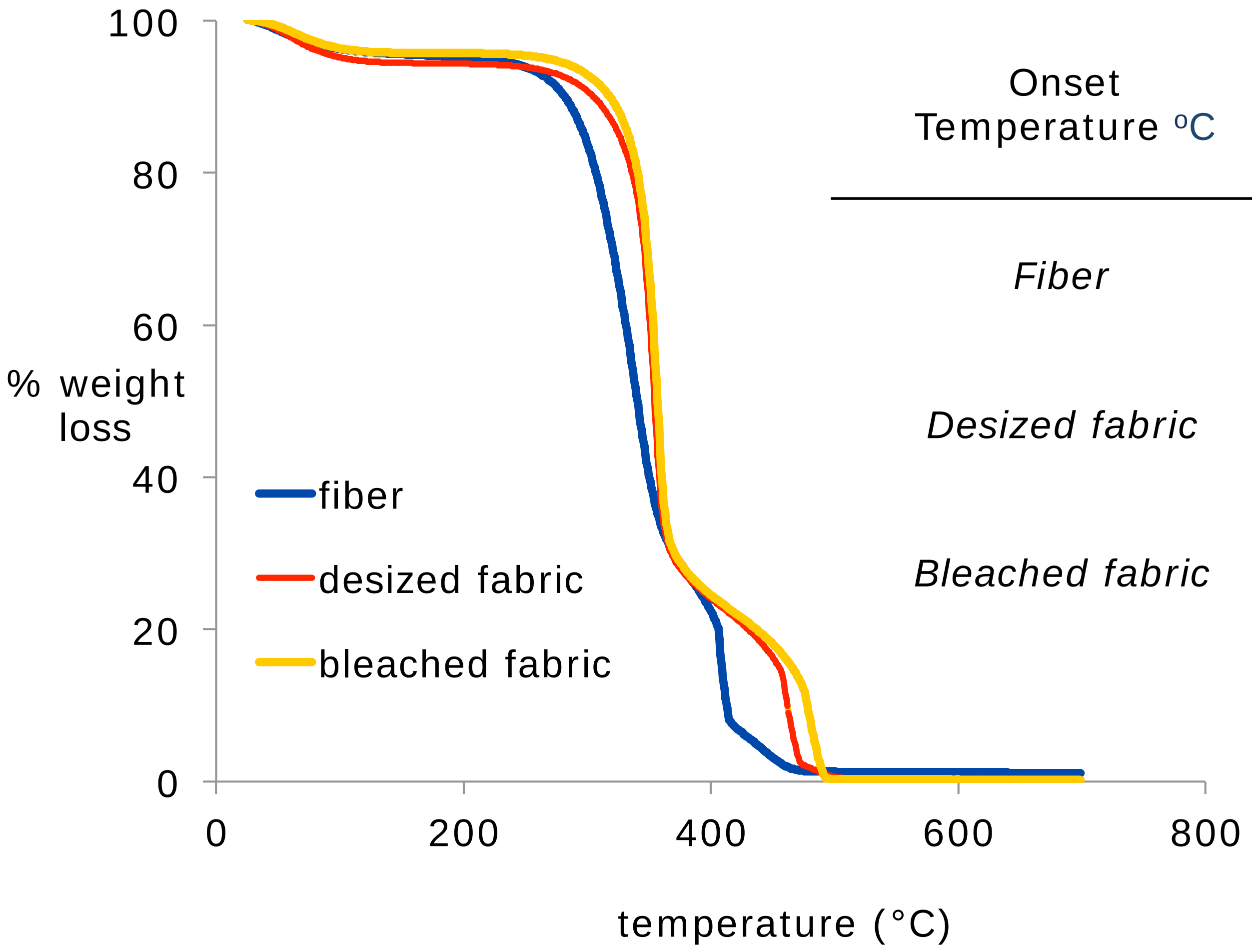
Second region

aliphatic char and volatiles

Third region

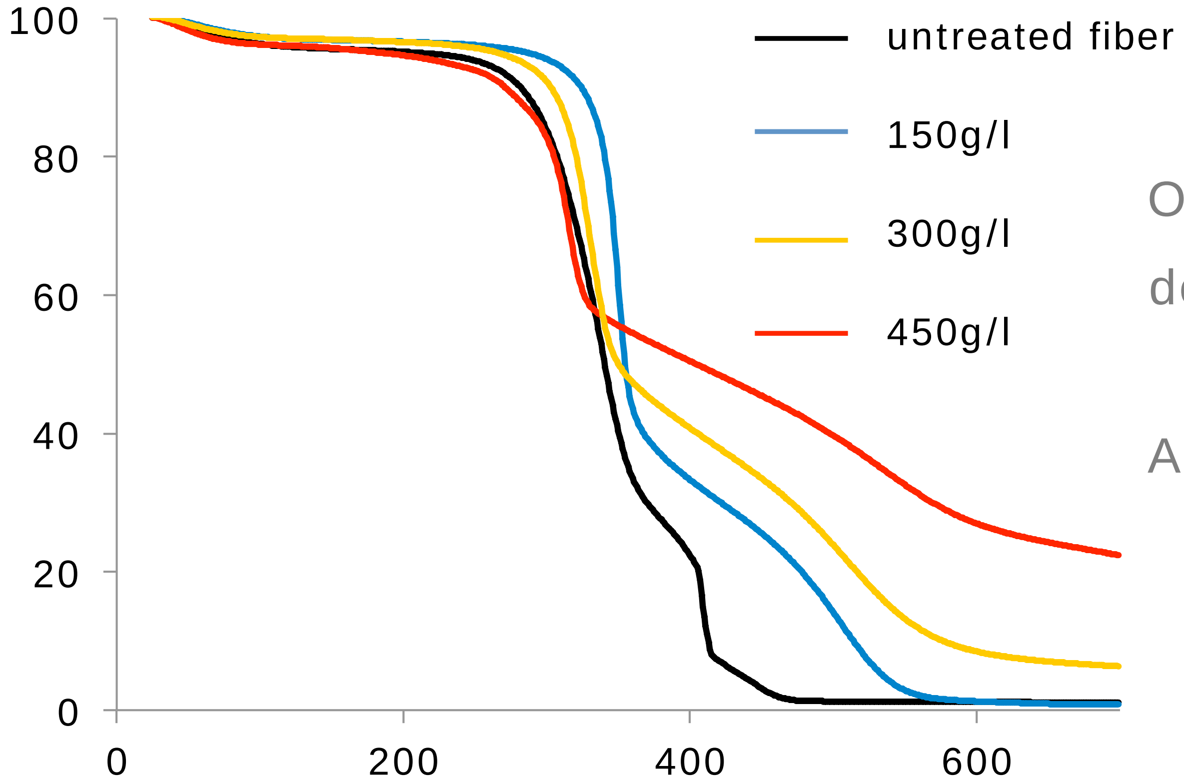
aliphatic char is oxidised

The second and the third decomposition onset T ºC differ between fibres and fabrics



Onset Temperature ºC	*1st decomposition*	*2nd decomposition*
Fiber	343 ºC	422 ºC
Desized fabric	353 ºC	466 ºC
Bleached fabric	361 ºC	502 ºC

The concentration of FR agent has an effect on TGA thermograms of fibres



Onset temperature of 1st decomposition decreases

Amount of char increases

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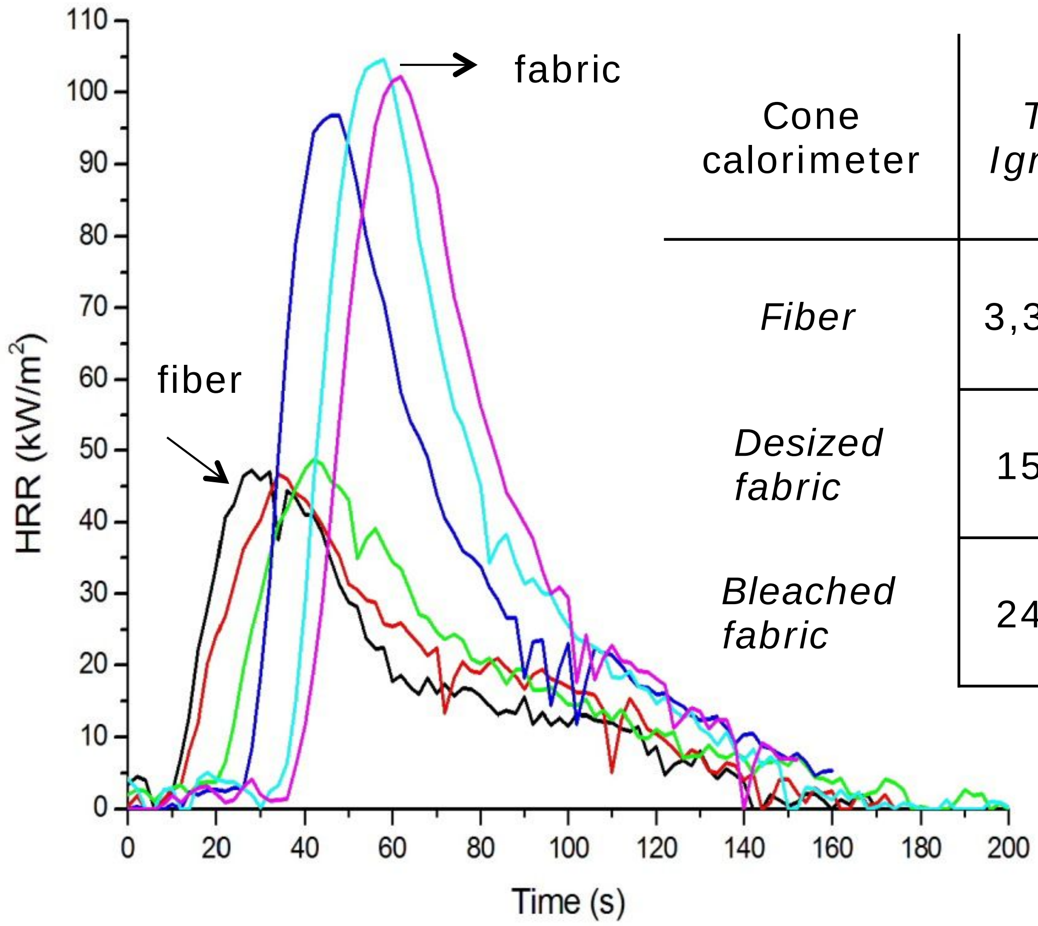
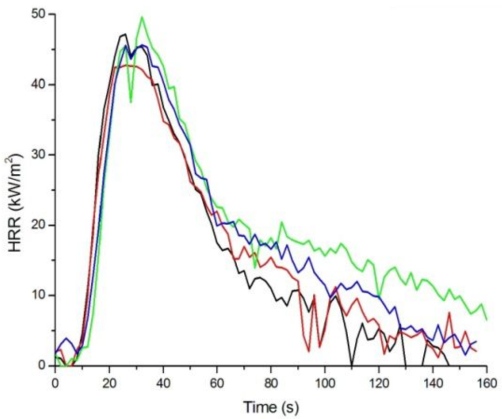
TTI, HRR and pK HRR values of fibres are quite different from fabrics

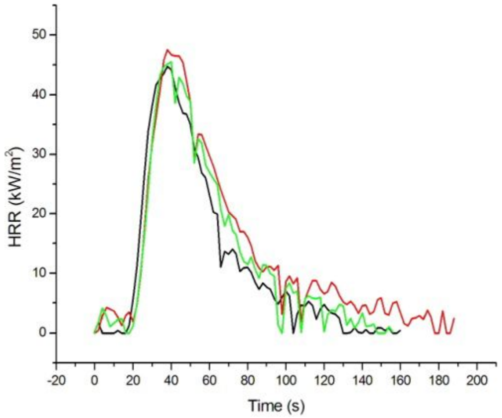


Cone calorimeter	*Time to Ignition (s)*	*pK Heat Release Rate* (kW/m^2)	*Heat Release Rate* (kW/m^2)
Fiber	3,33 ± 0,57	60,78 ± 3,35	35,39 ± 0,92
Desized fabric	15,0 ± 2,0	92,10 ± 4,18	47,60 ± 1,53
Bleached fabric	24,6 ± 7,5	101,3 ± 3,9	50,68 ± 2,59

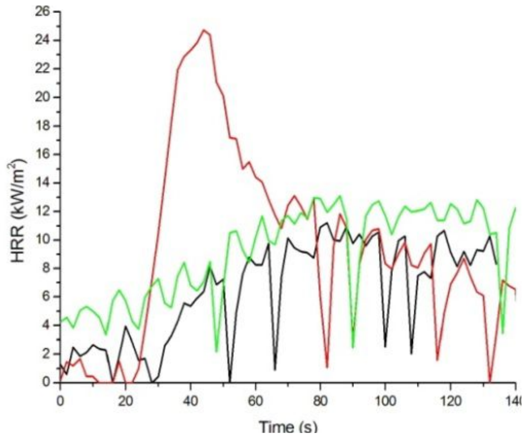
Differences between untreated and FR treated fibres can be observed by Cone test



untreated fibre



Low concentration



High concentration

Cone	TTI	pK HRR	HRR
untreated	5,3	46,3	28,4
Low	10,6	45,93	25,38
High	15	24,71	13,77

Small scale tests that reliably predict the performance of cotton fibres is essential

Reactivity

A small scale dyeing method is developed

A conventional spectro-photometric method is adapted

Flame retardancy

The feasibility of TGA was tested

Cone calorimeter was adapted for fibre samples

The preferred techniques are accurate and can be used for the evaluation of bioengineered cotton fibres

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