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ANTIMICROBIAL FINISH OF TEXTILES BY CHITOSAN UV-CURING

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ANTIMICROBIAL FINISHES

Presence of bacteria, gram positive and negative, and fungi producing mould, mildew or rot is common on textiles.

- Pathogenic
- Odour causing
- Damage of the textile

Textiles involved: natural or synthetic; industrial or home furnishing, clothes used in hospitals, schools, hotels, crowded areas; textiles left wet between process steps for long times.

Problem: finding a balance between high biocide activity and the requirements of safe handling, including non toxicity to humans and low environmental impact.

ANTIMICROBIAL FINISHES

- ~~**Metals and metal salts** → deactivation of proteins~~
- ~~**Quaternary ammonium salts** → membrane damage~~
- ~~**N-Halamines** → oxidative properties~~
- Others: **organic molecules** (e.g. Triclosan)

CHITOSAN

Chitosan either kills microorganisms (bacteriocidal) or simply inhibit their growth (bacteriostatic) by:

- Cell wall damage
- Inhibition of cell wall synthesis
- Alteration of cell wall permeability
- Inhibition of the synthesis of proteins and nucleic acids
- Inhibition of enzyme action

ADVANTAGES: natural substance, non-toxic, biodegradable, low cost, uv-curable, chemically boundable on cellulose due to its reactive hydroxyl groups

LIMITATIONS: poor acidic resistance and mechanical strength

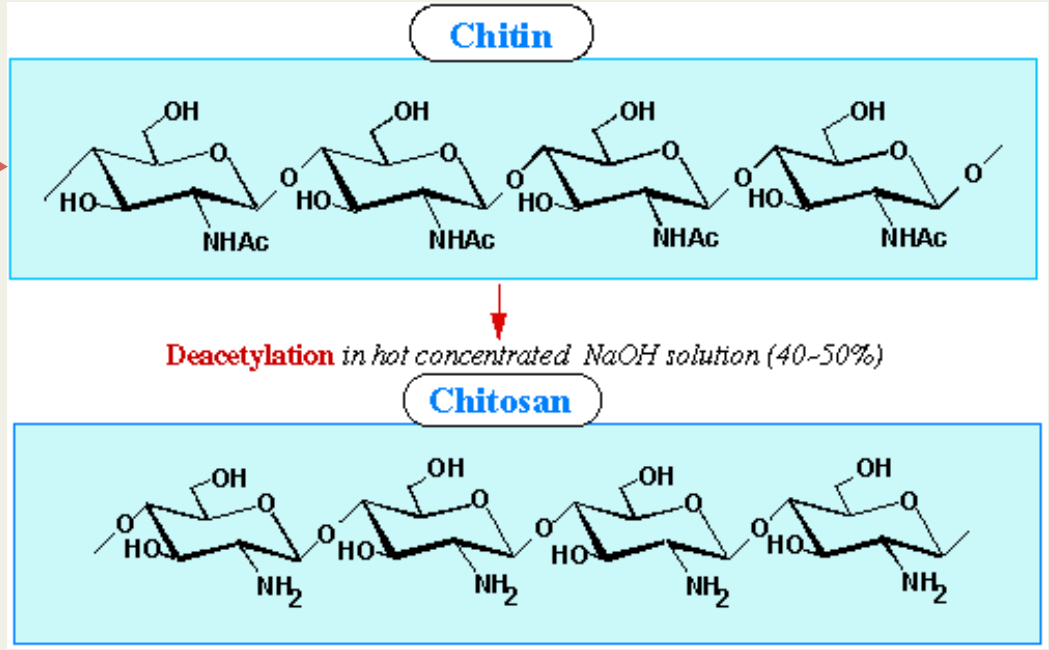
CHITOSAN

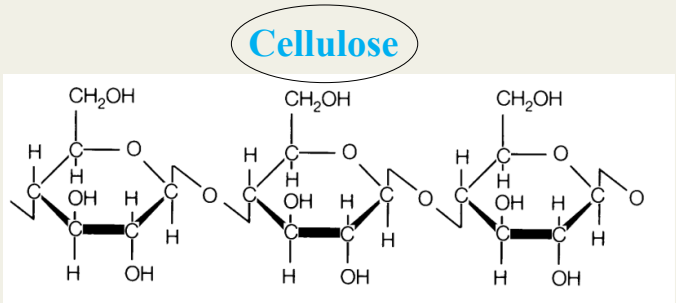
Chitosan (2-amino-2deoxy-(1→4)-β-D-glucopyranan), is a carbohydrate polymer derived from the **Chitin** component of the shells of crustacean, such as crab, shrimp and cuttlefish.

Decalcification *in dilute aqueous HCl solution*

Deproteination *in dilute aqueous NaOH solution*

Decoloration *in 0.5% $KMnO_4$ aq. and Oxalic acid aq. or sunshine*





CHITOSAN GRAFTING

Wet thermal curing involving **high temperatures** with **high energy consumption, costs** and possible **fabric degradation**; moreover the addition of **toxic compounds,** such as glutaraldeyde, is required as crosslinking agent.

UV-CURING

Radical **ultraviolet curing** of chitosan on textile fabrics, conferring **antimicrobial activity**.

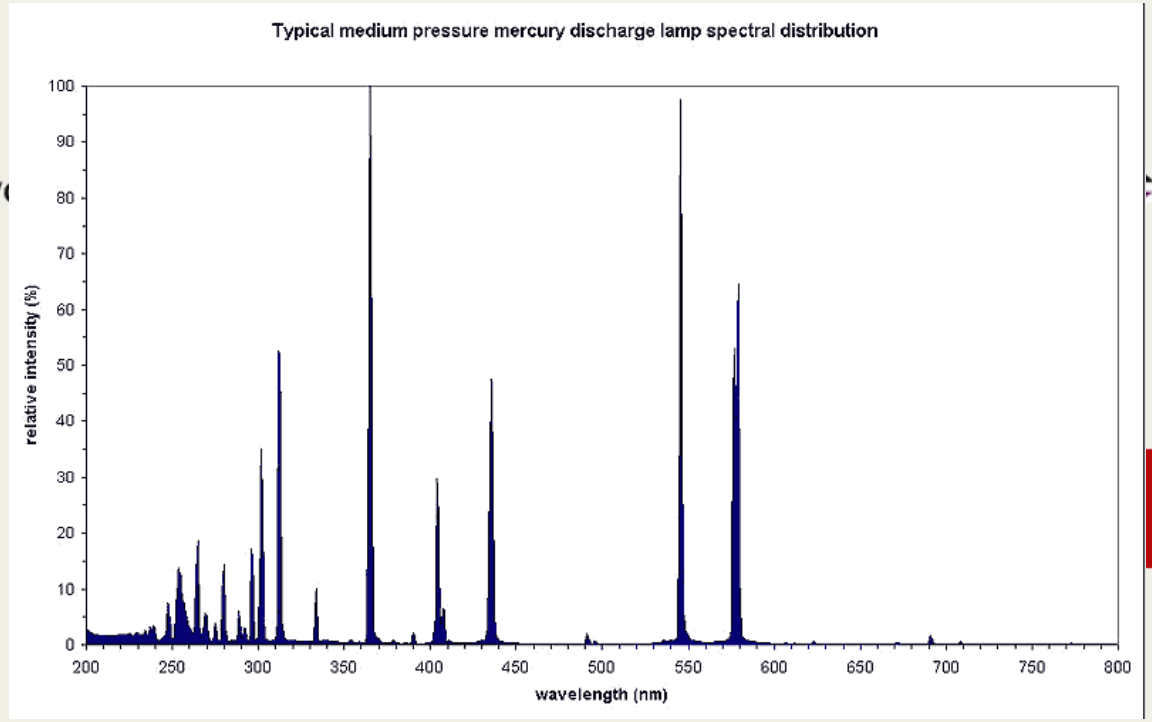
UV curing is very interesting for industrial applications: **energy savings** (low-temperature process), **low environmental impact** (no solvent emissions), **simple**, **cheap and small equipment**, **high treatment speed.**

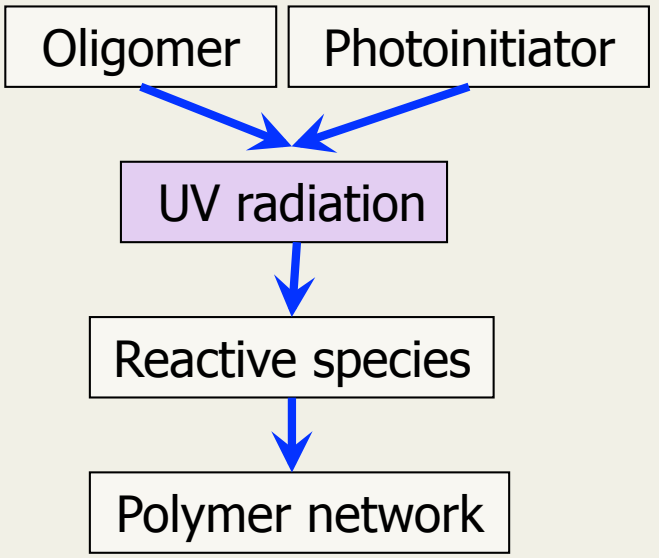
UV-CURING

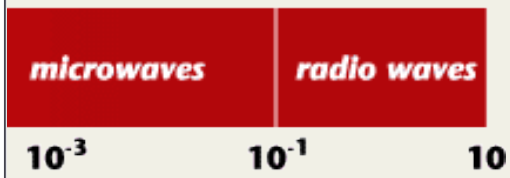
Ultraviolet curing is a process in which UV energy produced by a mercury discharge lamp is absorbed by a sensitizer, causing a reaction in the monomer which makes it hard and dry.

Photoinitiator

Chemical species which generate free radicals or ions under UV-irradiation.



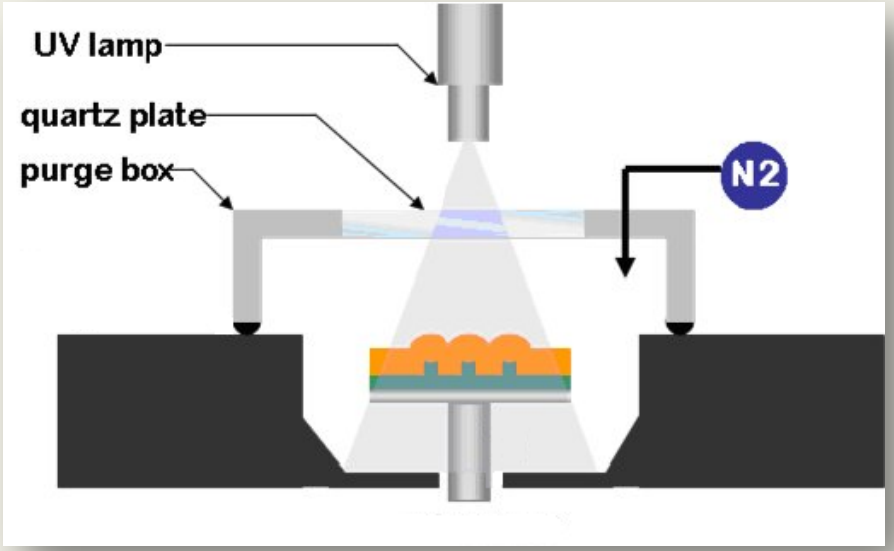




UV-CURING TECNIQUE

For the UV-curing of the chitosan on the fabrics the following steps are required:

- Chitosan dilution in 2% acetic acid solution
- Photoinitiator addition in the proper amount
- Spreading of the mixture on the fabrics
- Drying, at 80°C-100°C for 10 minutes
- UV-curing for 30-60sec, in inhert atmosphere



Apparatus 20 mW/cm² for inhert atmosphere exposition

BACKGROUND

Water-Repellent Finishing of Cotton Fabrics by Ultraviolet Curing

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Silk Grafting with Chitosan and Crosslinking Agents

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MATERIALS

FABRICS: plain-weave pure **cotton** (144g/m^2) previously washed but not subjected to any finishing process; **PET** filter fabrics 150 thread/cm, thread diameter 34 μm, 17% free surface, plasma treated, and 49 thread/cm, thread diameter 70 μm, 40% free surface, plasma treated; **polyamide** filter fabric 180 thread/cm, thread diameter 30 μm, 21% free surface, kindly supplied by SAATI.

ANTIMICROBIAL FINISH: **CHITOSAN low viscous** (Fluka), low molecular weight product, 75-85% deacetilation degree, 20-200 cps viscosity value of 1% solution in 1% acetic acid.

PHOTOINITIATOR: **Darocure 1173** (Ciba Specialty Chemicals) 2%wt for radical curing.

SOLVENT: **Acetic Acid** 2% solution (Fluka)

WEIGHT GAIN

$$\text{Weight gain (\%)} = \frac{w - w_0}{w_0} \times 100$$

Where: **w** = weight of grafted fabric

w_0 = weight of original fabric

Investigated : 3% < WG% < 20%

GOOD RESULTS: WG% < 5%

GEL CONTENT EVALUATION

It was determined on the cured fabrics by measuring the weight loss after washing according UNI-EN ISO 105-C01 using ECE detergent, followed by drying in oven at 90°C for 1h. Gel content can be considered a true polymerization yield, because the unpolymerized chitosan is removed by the solvent.

	weight on	% gel
PE_150	5%	93%
PE_49	0,8%	100%
PA	1,6%	100%

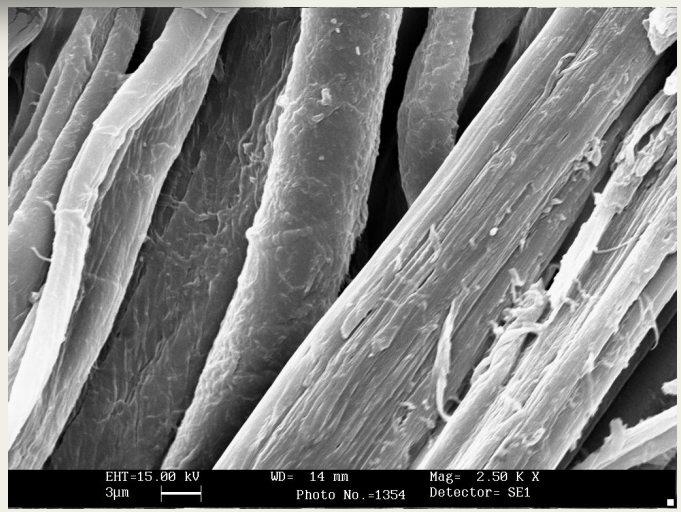
Average %gel values

ANTIMICROBIAL ACTIVITY DETERMINATION

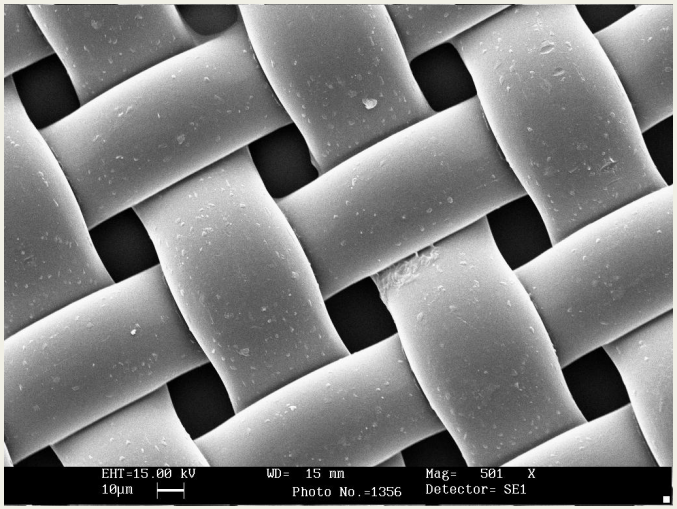
ASTM E 2149-01 "Standard test method for determining the antimicrobial activity of immobilized antimicrobial agents under dynamic contact conditions"
BACTERIA: Escherichia Coli ATCC 8739

MATERIAL	% WEIGHT ON	DILUTION	% REDUCTION ORGANISM
Cotton	2,3%	Not diluted	100%
Cotton	1,1%	Water	99,3%
Cotton	1,5%	Acetic acid 2%	96,9%
PA	3,14%	Not diluted	100%
PE_49	1,28%	Acetic acid 2%	86,7%
PE_150	1,13%	Acetic acid 2%	98,4%
Chitosan film	-	-	100%

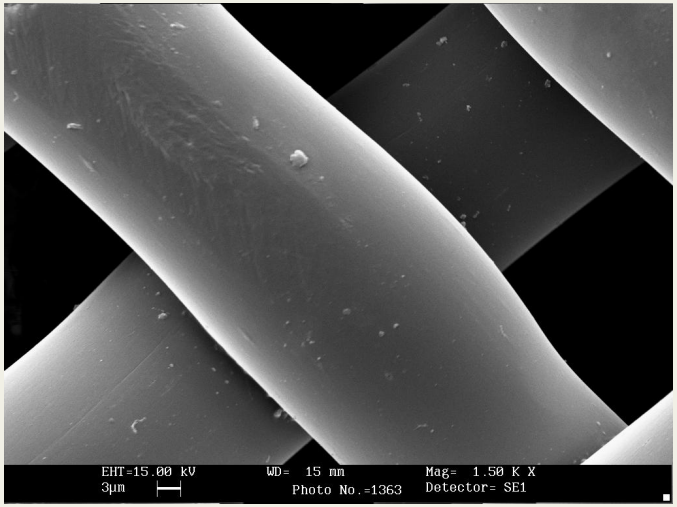
SEM ANALYSIS



Cotton Chitosan 3% weight gain



PE_150 Chitosan 1% weight gain



PA Chitosan 1% weight gain

FASTNESS TEST

MATERIAL	% WEIGHT ON	CONTACT TIME	DILUTION	%REDUCTION ORGANISM
Cotton	2,4%	-	Not diluted	5,6%
Cotton	1,1%	-	Water	4,2%
Cotton	1,5%	-	Acetic acid 2%	30,8%
Cotton	3%	12h	Acetic acid 2%	97,2%
PE_49	1,5%	12h	Acetic acid 2%	96,9%
PE_150	1%	3h	Acetic acid 2%	22,4%
PA	1,5%	3h	Acetic acid 2%	45,7%

Values after 5 cycles treatment fastness to domestic washing test (UNI-EN ISO 105-C01)

DYEING TEST_COTTON

Chitosan confers dyeability to fabrics, so the chitosan presence and the treatement homogeneity was tested dyeing fabrics with Turquoise Telon acid dye (DyStar).

Cotton untreated

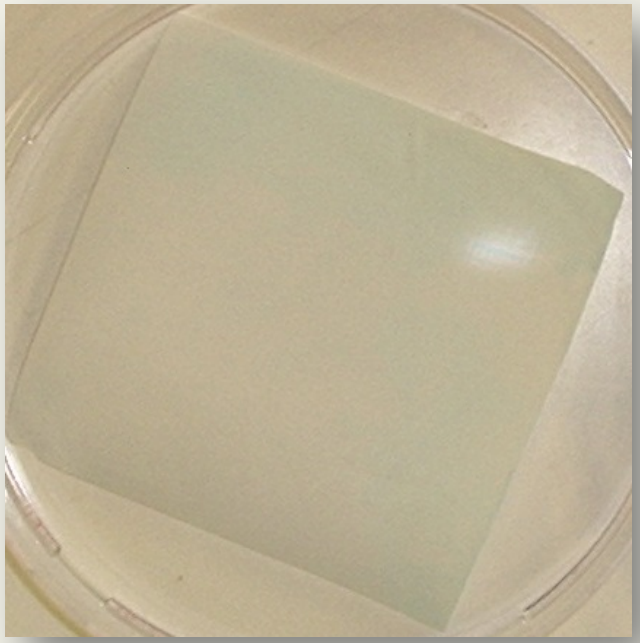
Cotton chitosan treated

Cotton chitosan treated and washed

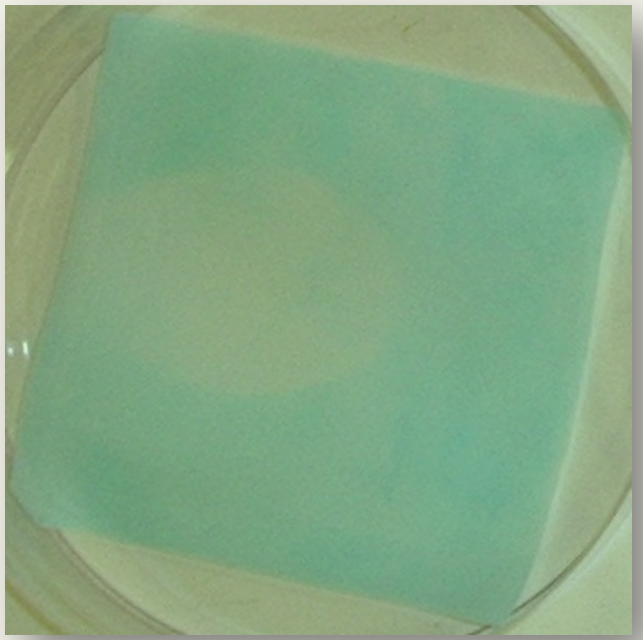
- Treatment homogeneity
- Chitosan presence after washing

DYEING TEST_PE

PE_150 untreated



PE_150 chitosan treated



- Treatment homogeneity

NINHYDRIN ASSAY

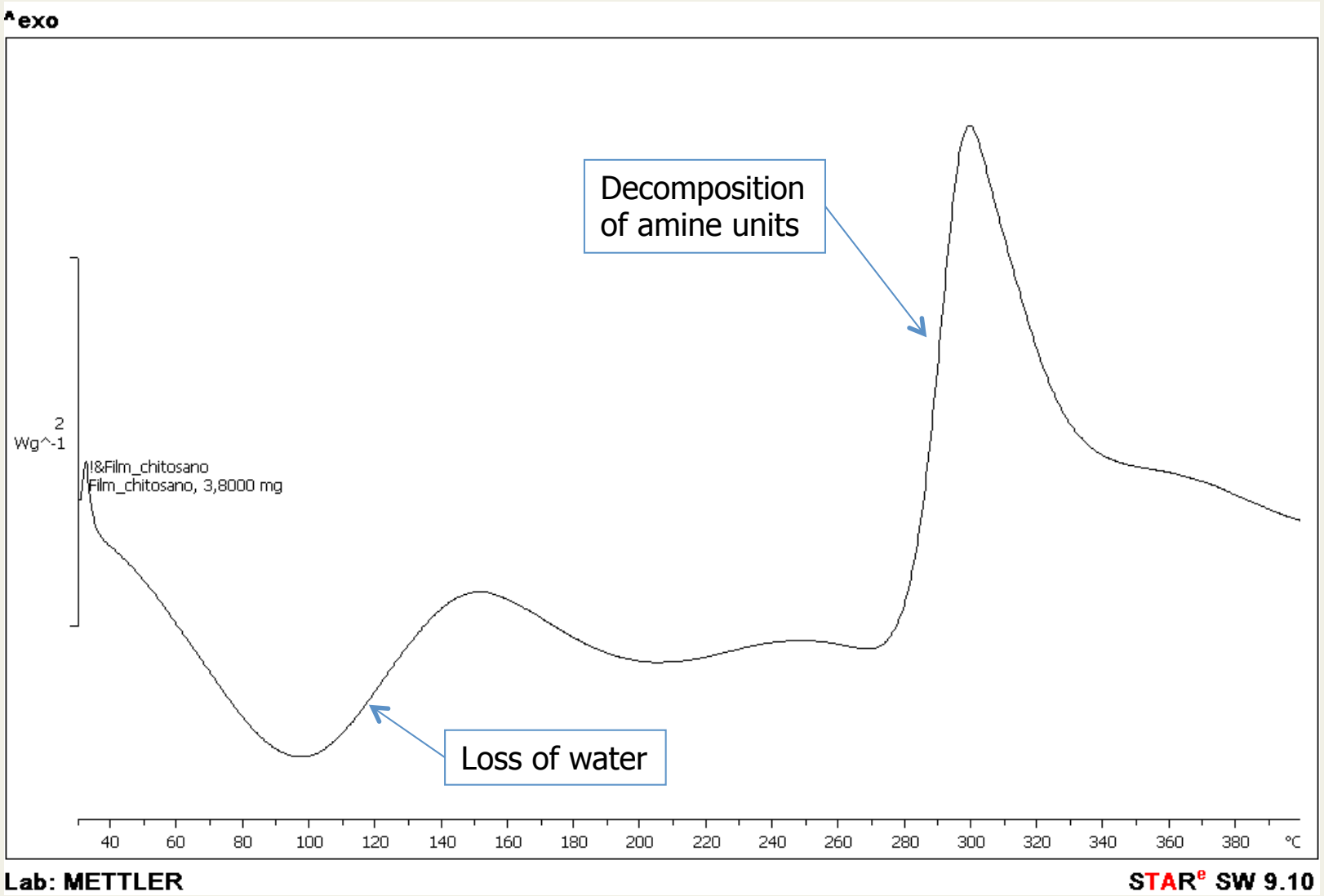
WASHING CYCLE	FREE AMINO GROUPS [10^{-3} mmol/g]
0	*44,13*
1	*41,24*
2	*42,20*
3	*36,43*
4	*47,97*
5	*36,43*

Cotton 4,8% chitosan weight on

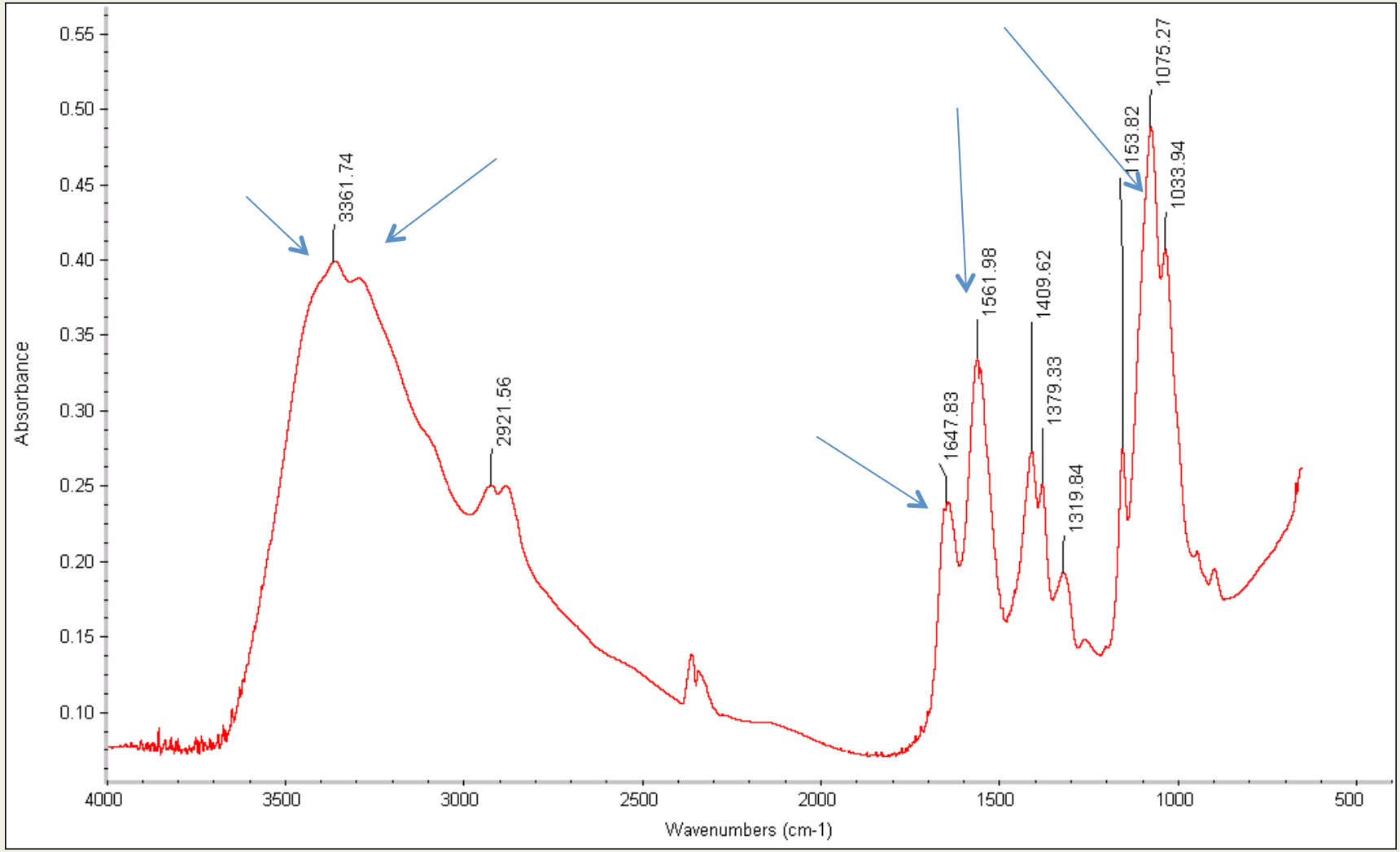
Cotton 2,6% chitosan weight on

WASHING CYCLE	FREE AMINO GROUPS [10^{-3} mmol/g]
0	*7,58*
1	*5,74*
2	*5,66*
3	*8,54*
4	*8,54*
5	*9,51*

DSC ANALYSIS ON CHITOSAN FILM



FTIR-ATR ANALYSIS ON CHITOSAN FILM



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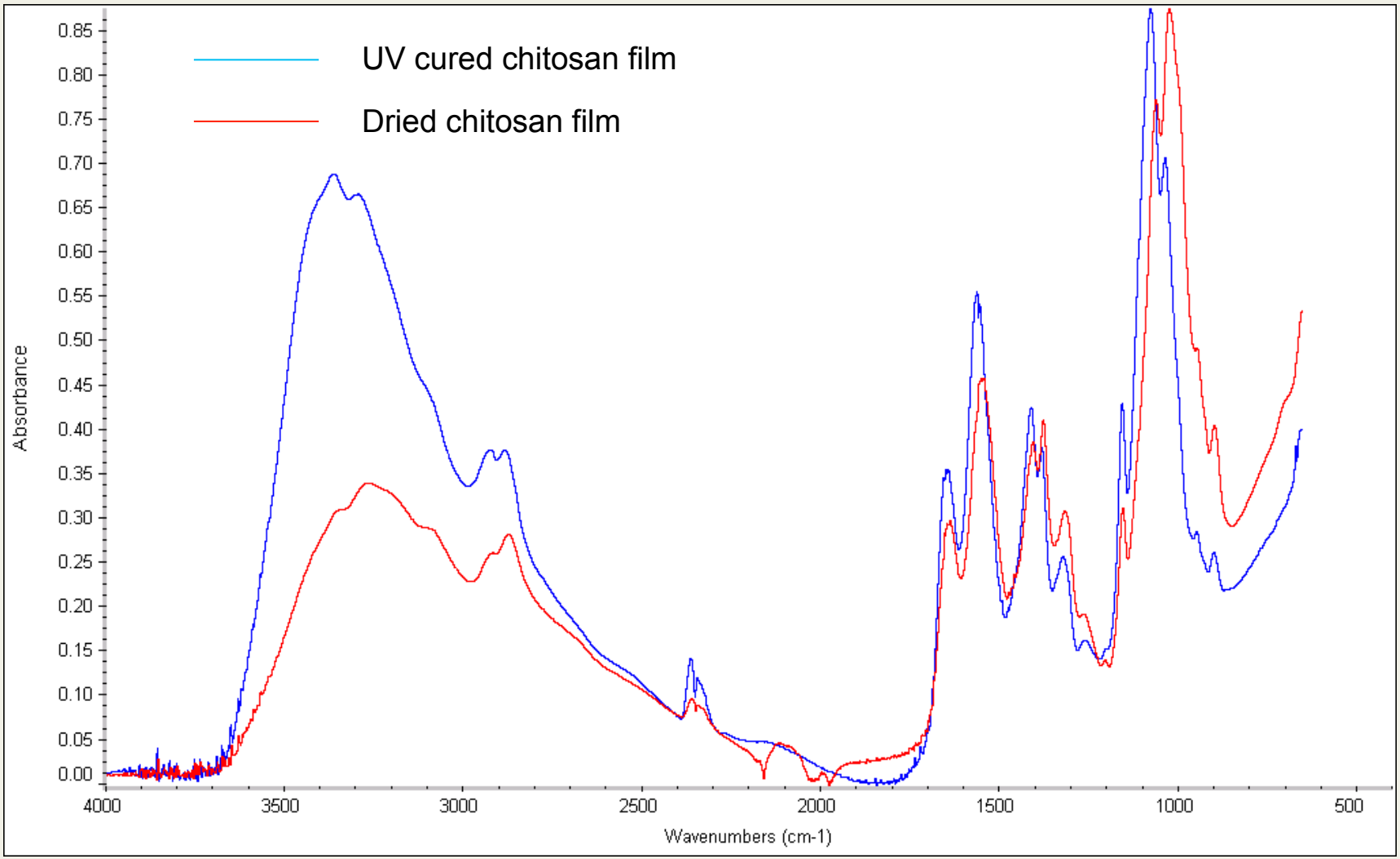
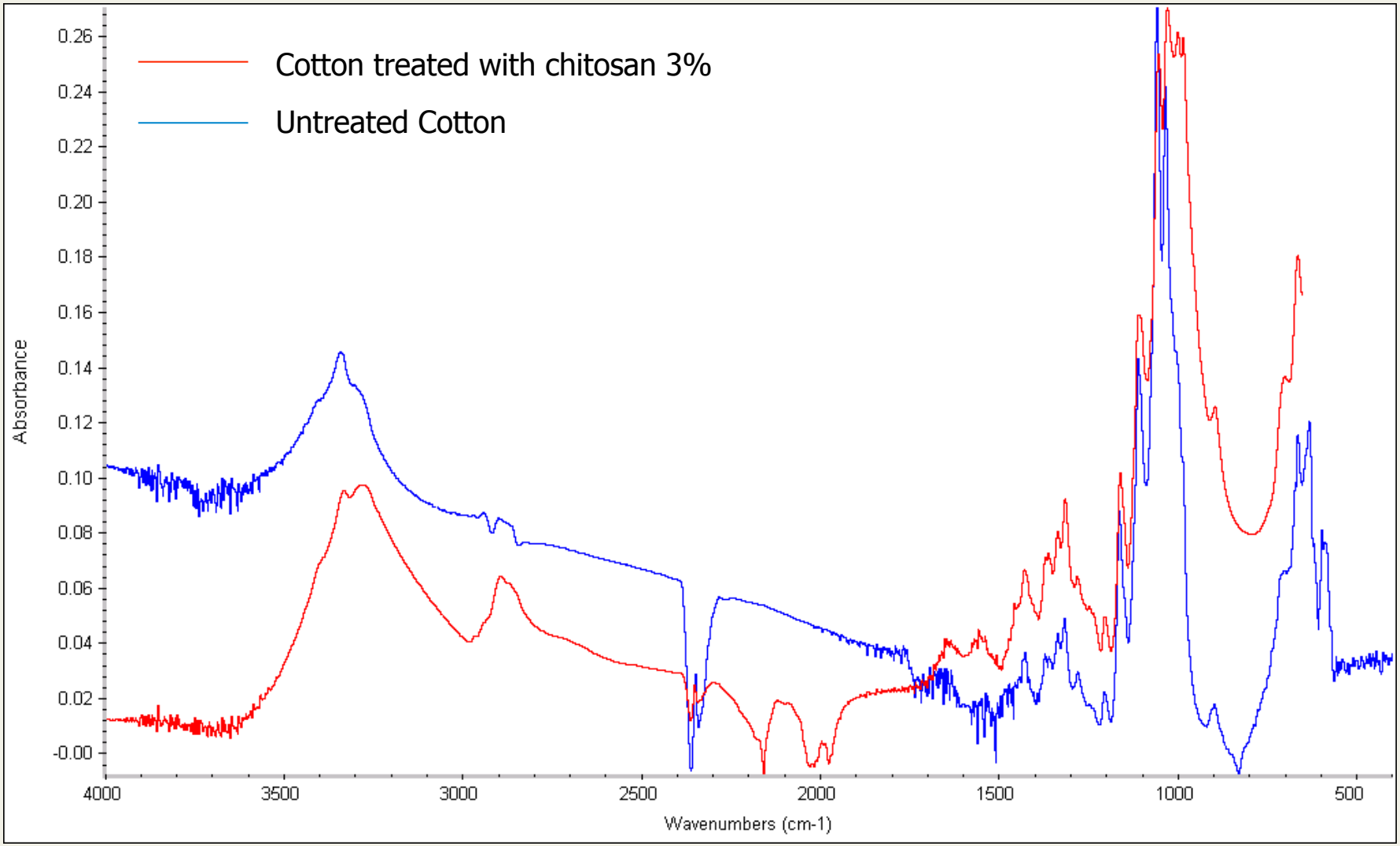
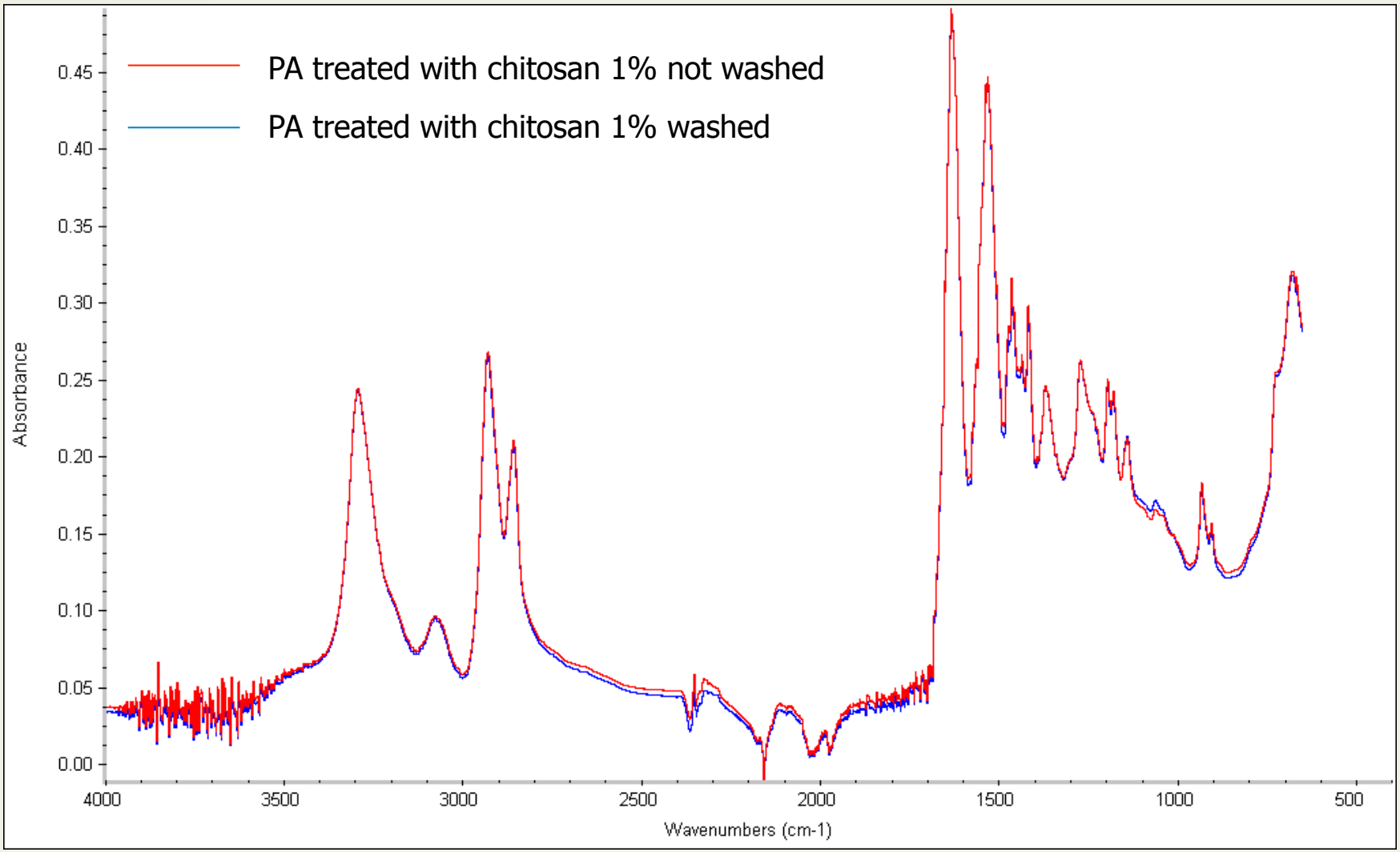


FTIR-ATR ANALYSIS



FTIR-ATR ANALYSIS



FUTURE WORK

On chitosan we are planning:

- **STUDY ON CHITOSAN UV-CURING MECHANISM AND INTERACTION WITH ANIONIC SURFACTANT**
- **REDUCTION OF CONTACT TIMES USING A SONICATED AND THERMO CONTROLLED BATH FOR IMPREGNATION**
- **DEEPER STUDY ON TREATMENT FASTNESS**
- **BIOMEDICAL APPLICATIONS**

But also:

- **UV-CURING ON TEXTILE FABRICS OF PYRROLE OBTAINING CONDUCTIVE TEXTILES WITH ANTIMICROBIAL ACTIVITY**

CONCLUSION

Research study on an innovative application of UV-curing for multifunctionalization of textiles, followed by a deep characterization of finished fabrics.

Application of a natural biopolymer by an ecofriendly process to confer antimicrobial activity to textiles.

Cheap equipment, with easy insertion in industrial process.
Chitosan is a low cost product, widely used in many different fields.


THANK YOU FOR
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ATTENTION !