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Novel Approaches to Process Bamboo Plants into Fibres and their UV-blocking Property

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Why Bamboo?

Serving daily need of mass people

Amazingly fast growth rate

Multifunctional and eco friendly

Medicine, construction, cosmetics...

No or Low pesticides and irrigation

Outstanding Carbon neutral activity!

(Austin, Ueda & Levy 1970, Bystriakova et al. 2003; Cusack 1999, Das & Chakraborty 2008, Farrelly 1984, Franklin et al. 2010; Gritsch & Murphy 2005, Hidalgo-Lopez 2003, Isagi et al. 1997, Jain et al. 1992, Liese 1998, Liese & Parameswaran 1976, Shan et al. 2008, Lu et al. 2005, Yen & Lee 2011, Ueda 1960)

Motivation: myth of bamboo textiles

Present non eco-friendly harmful production method. i.e. viscose method

Can the unique properties of bamboo be retained into fibres??

Green?

UV protection?

Antimicrobial?

My Research Question:

“To **develop** an eco-friendly manufacturing method to process bamboo plants into fibre without loosing the unique properties.”

Characterisation of Raw Bamboo

Morphology: Scanning Electron Microscope (SEM) and Confocal Microscope.

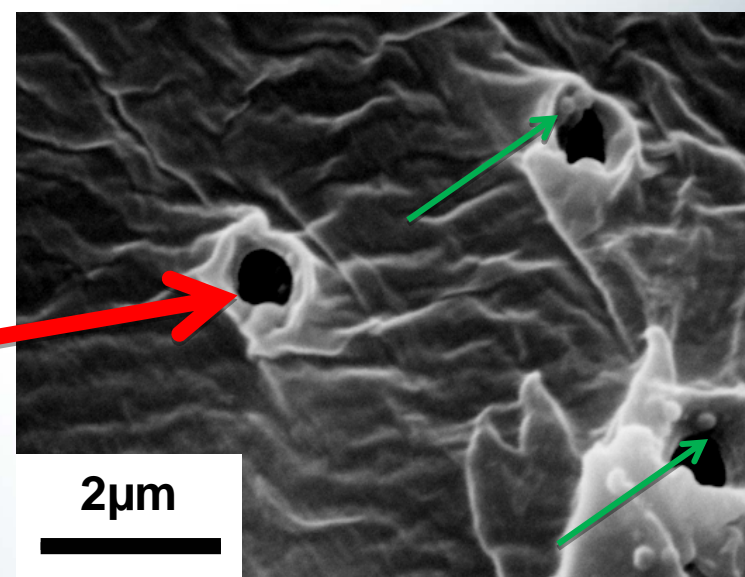
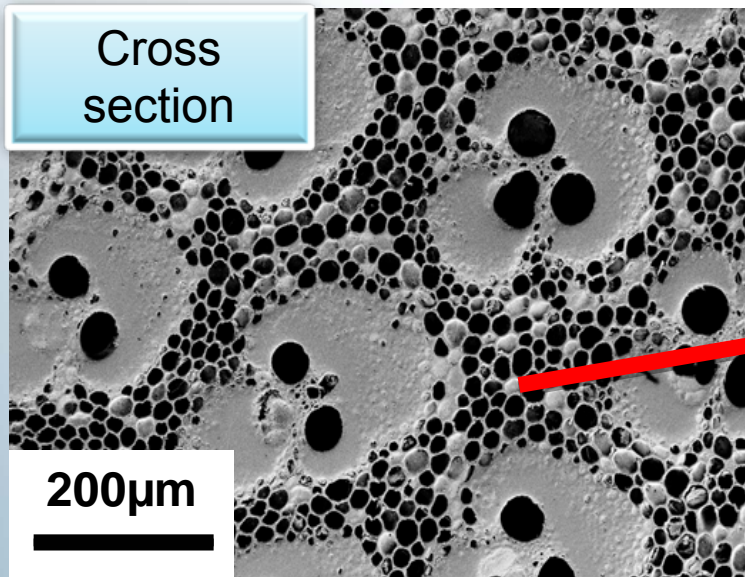
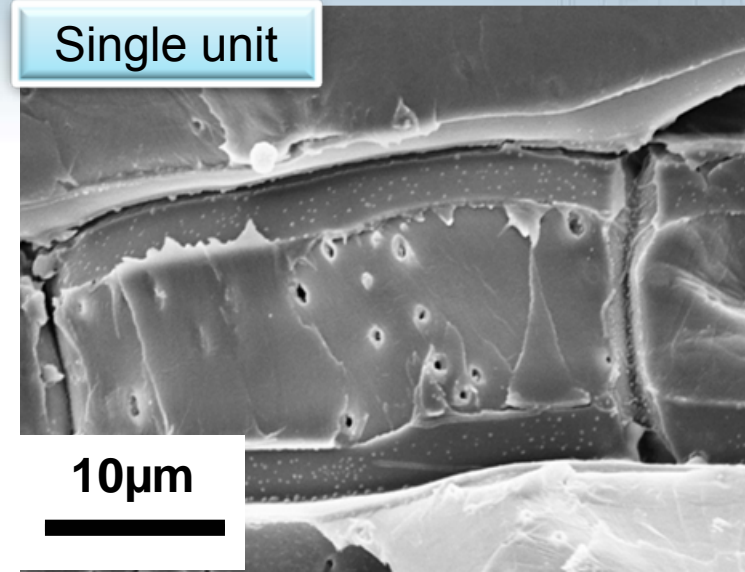
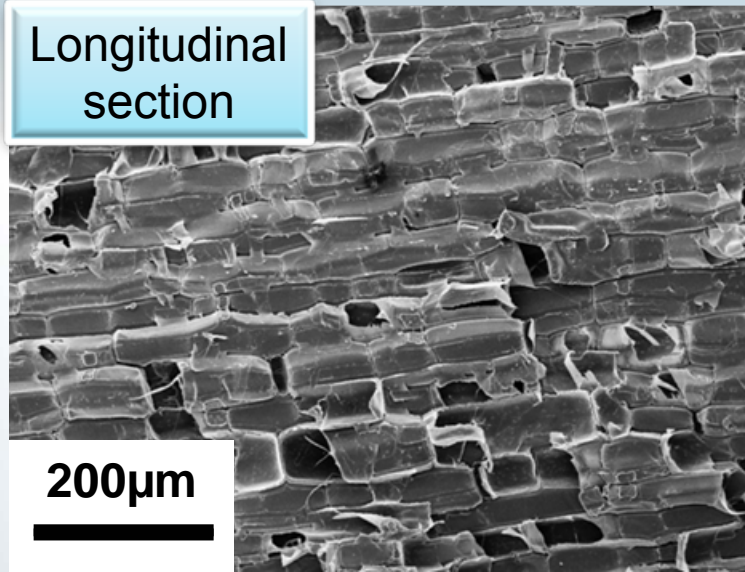
Australian grown:
Phyllostachys pubescens

Crystalline structures : X-ray Diffraction (XRD).

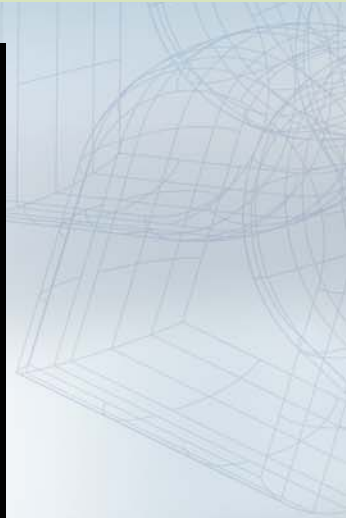
Chemical constituents analysis: Chinese standard: GB5889-86.

Chemical bonds analysis: Fourier Transform Infrared Spectroscopy (FT-IR).

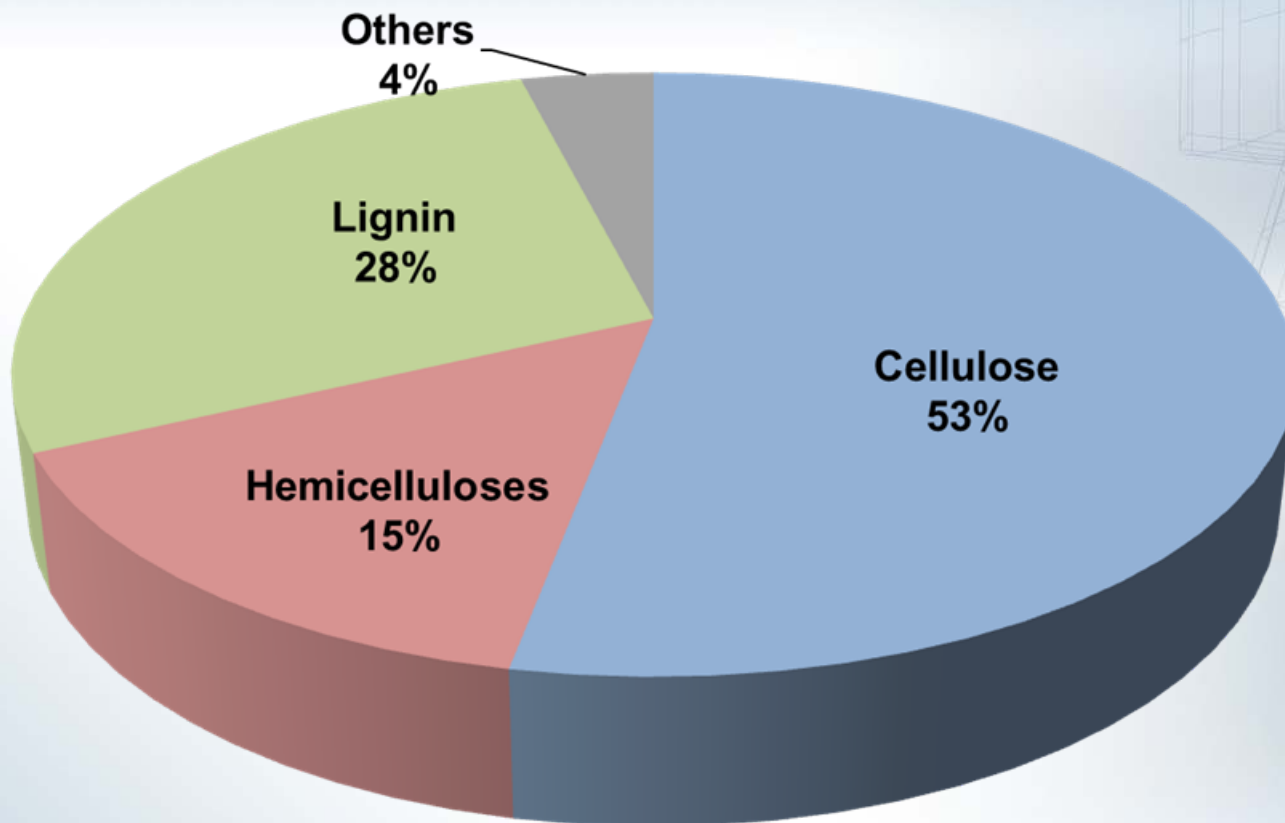
Morphology of raw bamboo (under SEM)



Under confocal microscope

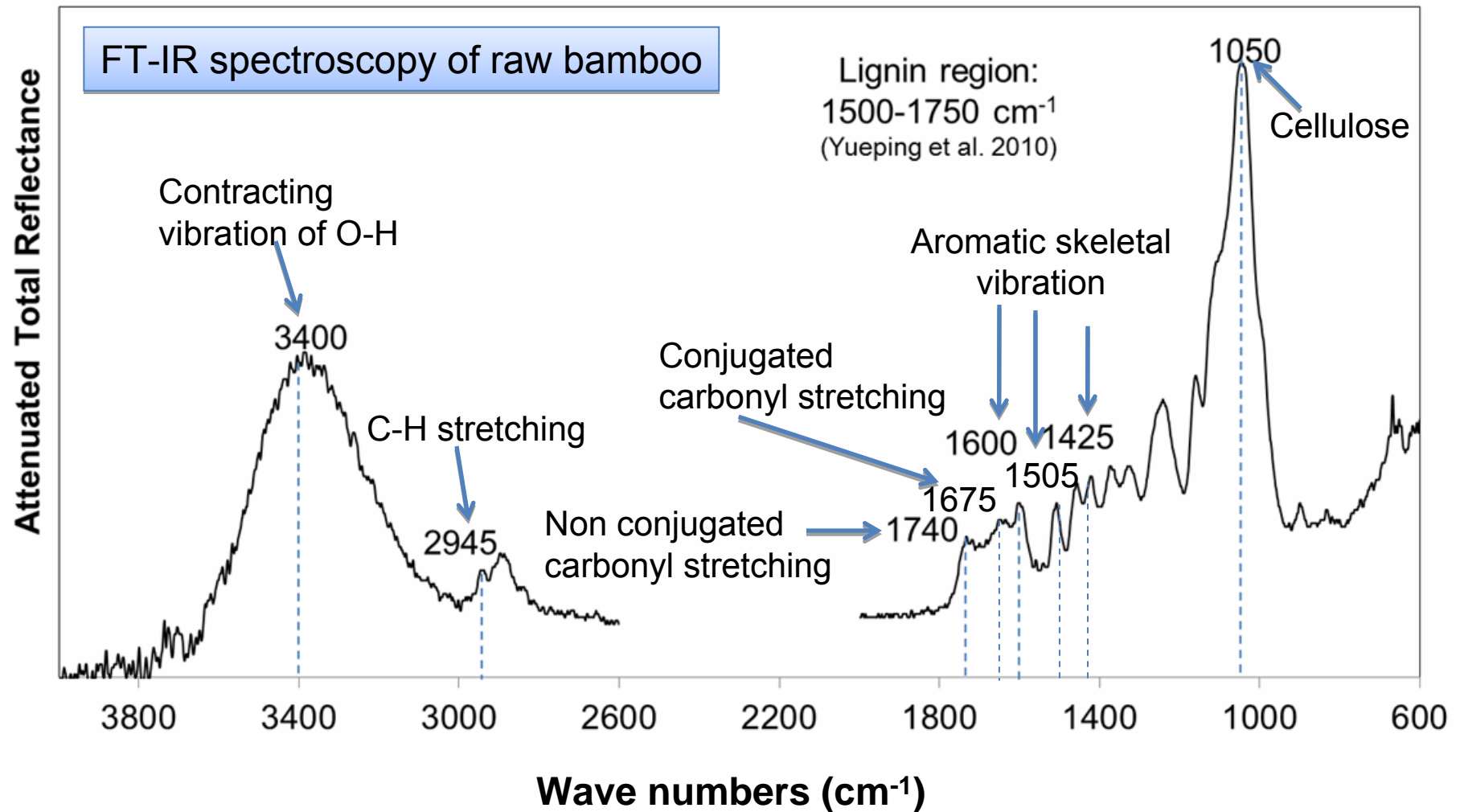


Chemical constituents analysis

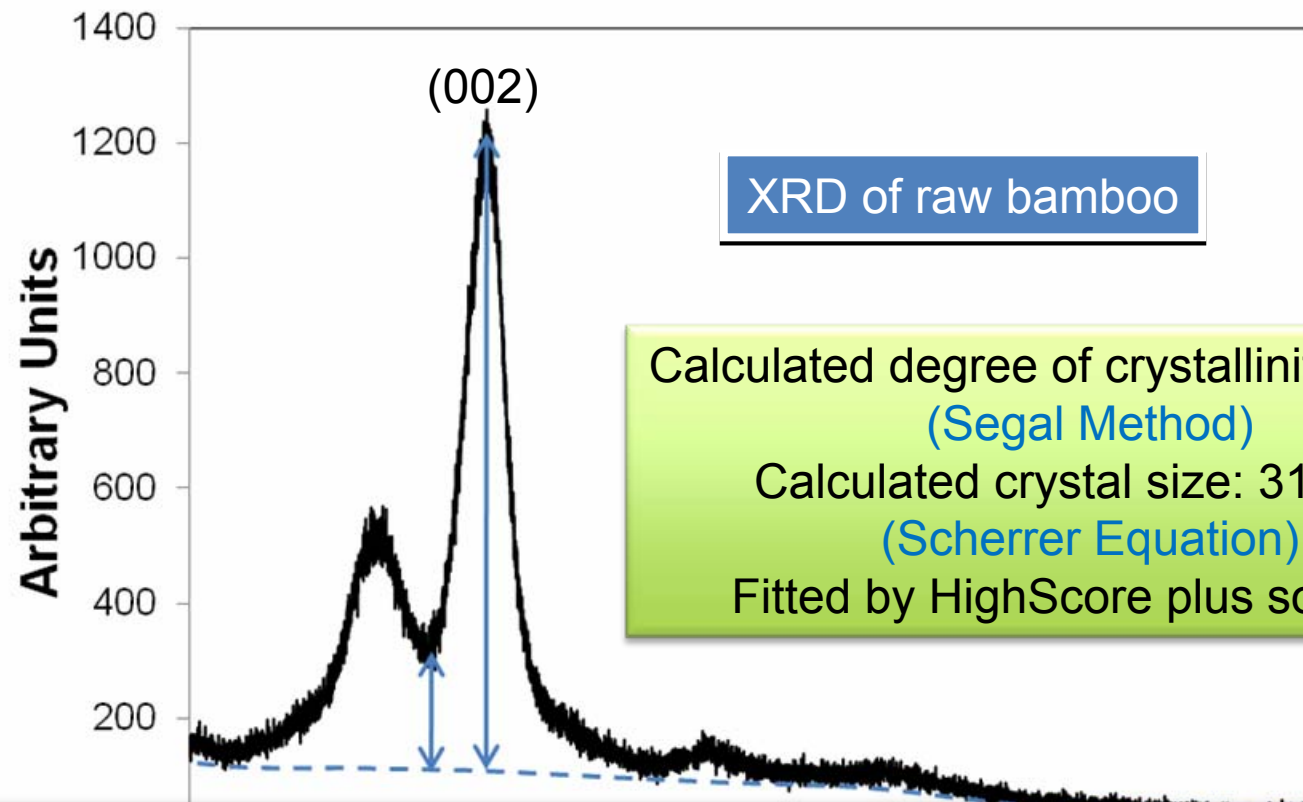


According to Standard:
GB5889-86

Functional chemical bonds in raw bamboo



Crystalline structure of raw bamboo



Calculated degree of crystallinity: 81-83%
(Segal Method)

Calculated crystal size: 31-40 Å
(Scherrer Equation)

Fitted by HighScore plus software

According to Segal Method:

$$X_c = \frac{I_{002} - I_{am}}{I_{002}} \times 100\%$$

Where, I_{002} is the peak intensity from the (002) lattice plane ($2\theta=22.6^\circ$) and I_{am} the peak intensity of amorphous phase ($2\theta=19^\circ$).

Origin of the UV shielding Characteristic of Raw Bamboo

Extractions

- **Polar**

Protic: Ethanol and water;

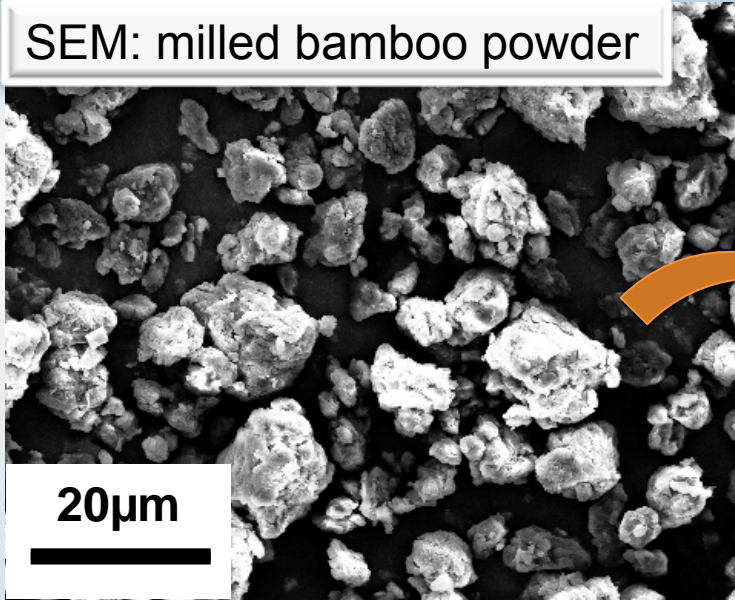
Aprotic: Acetone and
Dimethyl Sulfoxide (DMSO)

- **Non-polar** (Hexane and
Toluene)

- **Mixture of non polar and
polar** (dioxane: water=9:1)/
MWL extraction (Björkman,
1956)

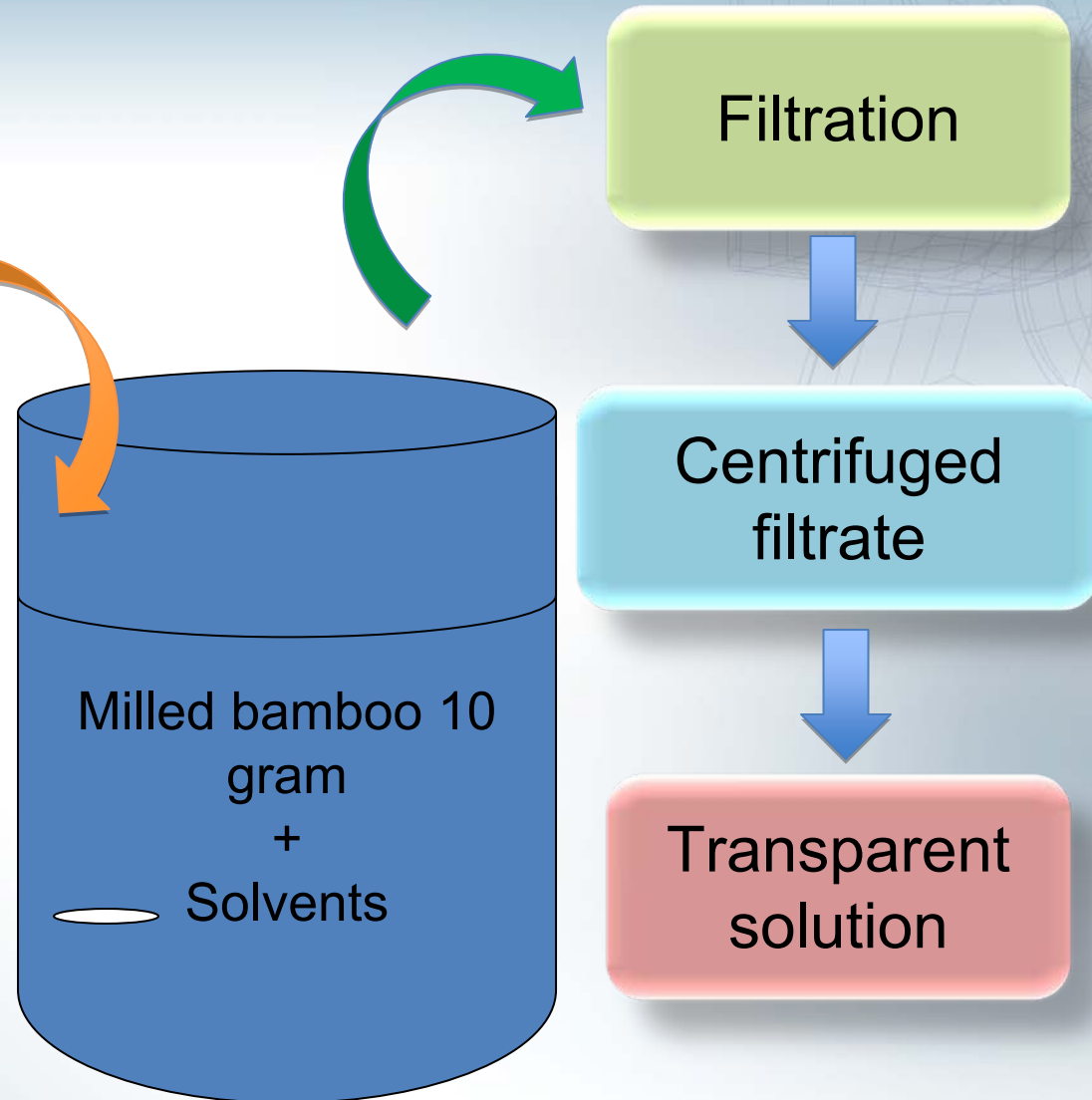
Bamboo extractions

SEM: milled bamboo powder

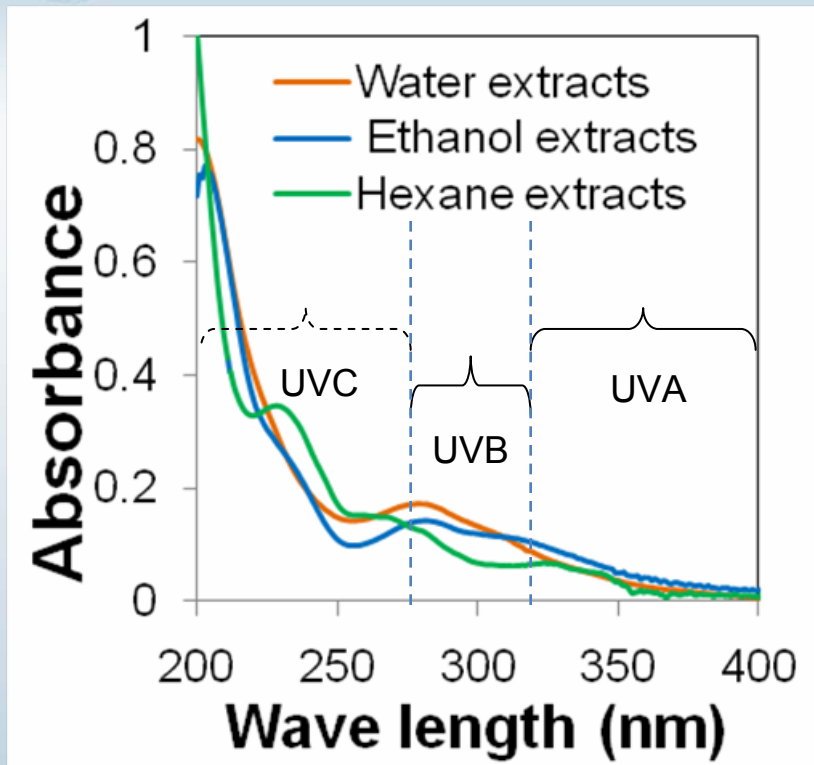


Material : Liquor
= 1:30

Time:
72 hours



UV absorbance of raw bamboo extracts

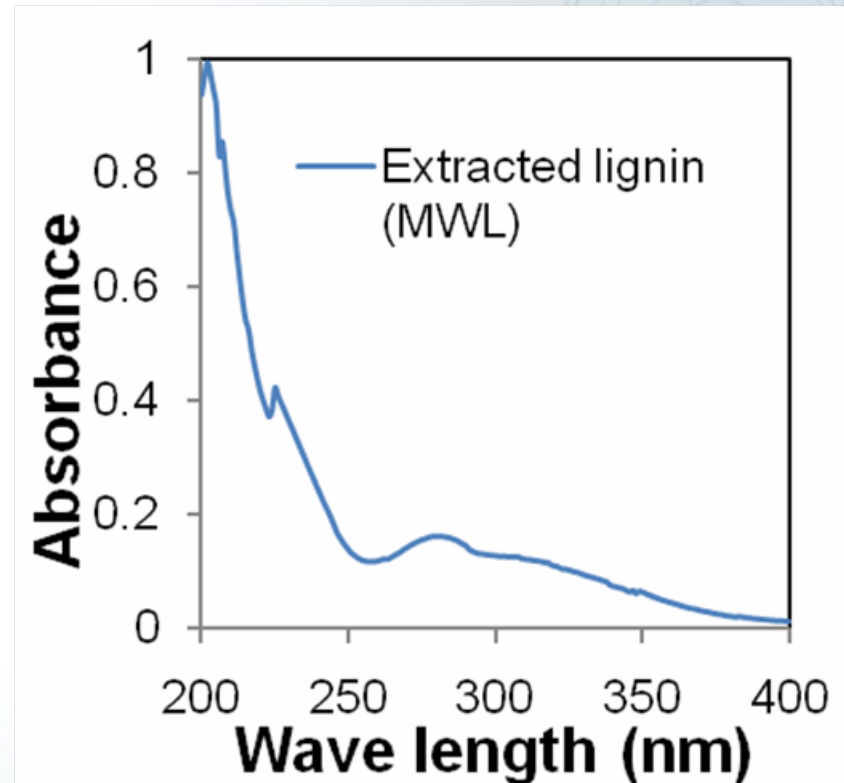


UVA: 315-400 nm

UVB: 280-315 nm

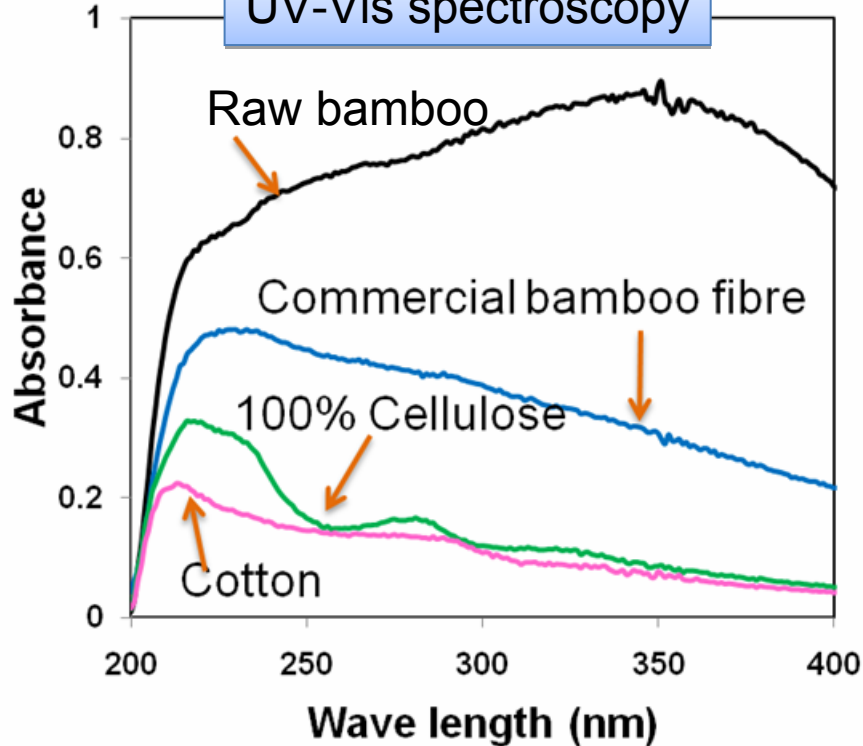
UVC: 100-280 nm

- More than **one** UV responsible component (Afrin et al., 2011).



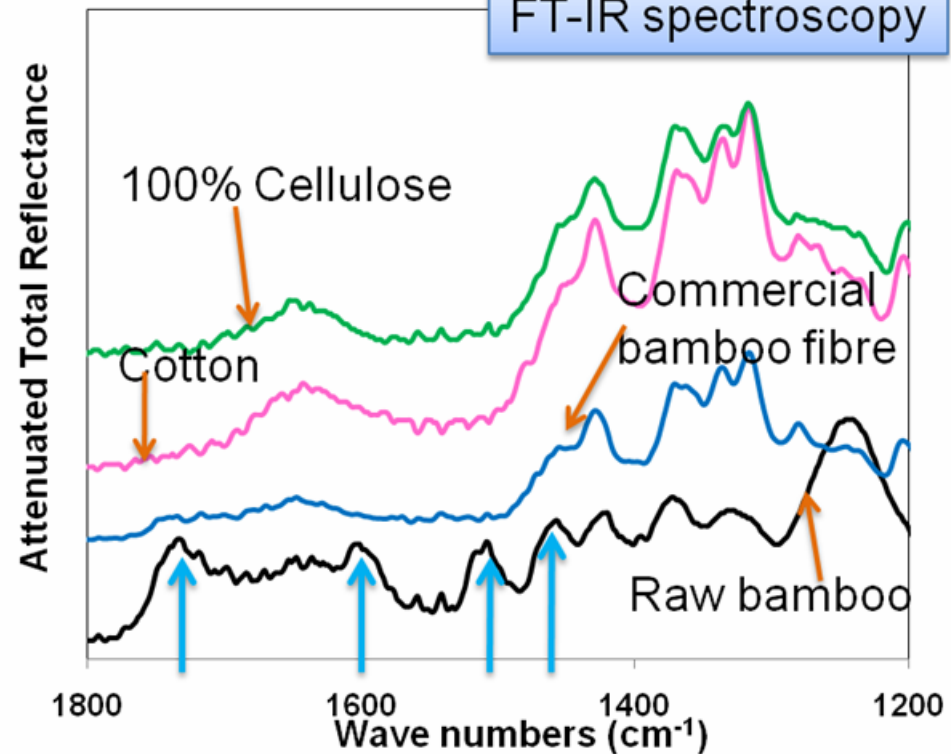
Relation between UV absorbance and chemical bonds of lignin

UV-Vis spectroscopy



Solid state

FT-IR spectroscopy



- Chemical components of lignin is contributing in UV blocking (Afrin et al., 2011).

Origin of the Antimicrobial Property of Raw Bamboo

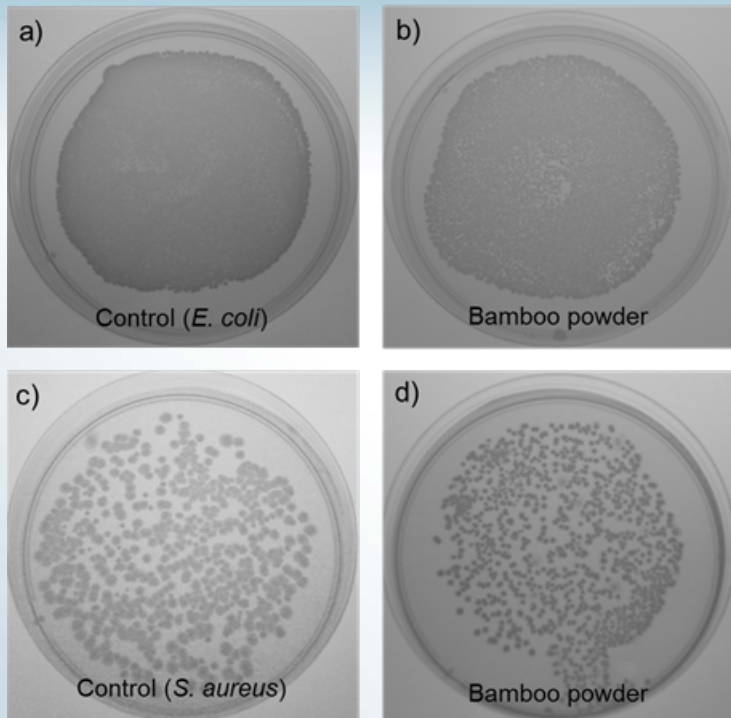
Challenge Bacteria: Gram negative bacteria, ***Escherichia coli*** (*E. coli*): ATCC 25922 and gram positive bacteria ***Staphylococcus aureus*** (*S. aureus*): ATCC 25923

Test standard: AATCC 100-2004 (clause 10.2) with slight modification.

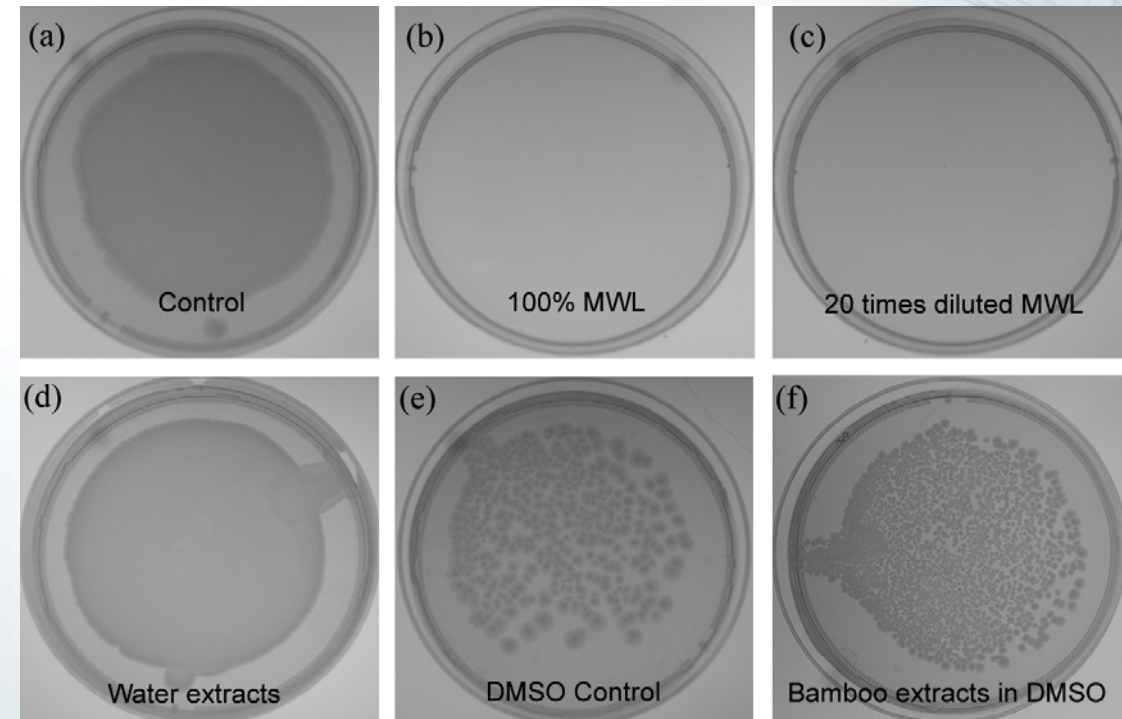
Samples:

- Bamboo Powder
- Bamboo extracts in water.
- Bamboo extracts in 90% aqueous dioxane (MWL). (after extraction dioxane is evaporated)
- Bamboo extracts in DMSO

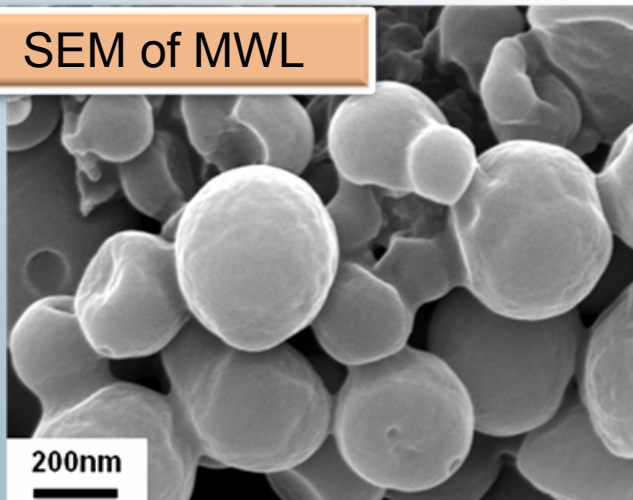
Antimicrobial test results



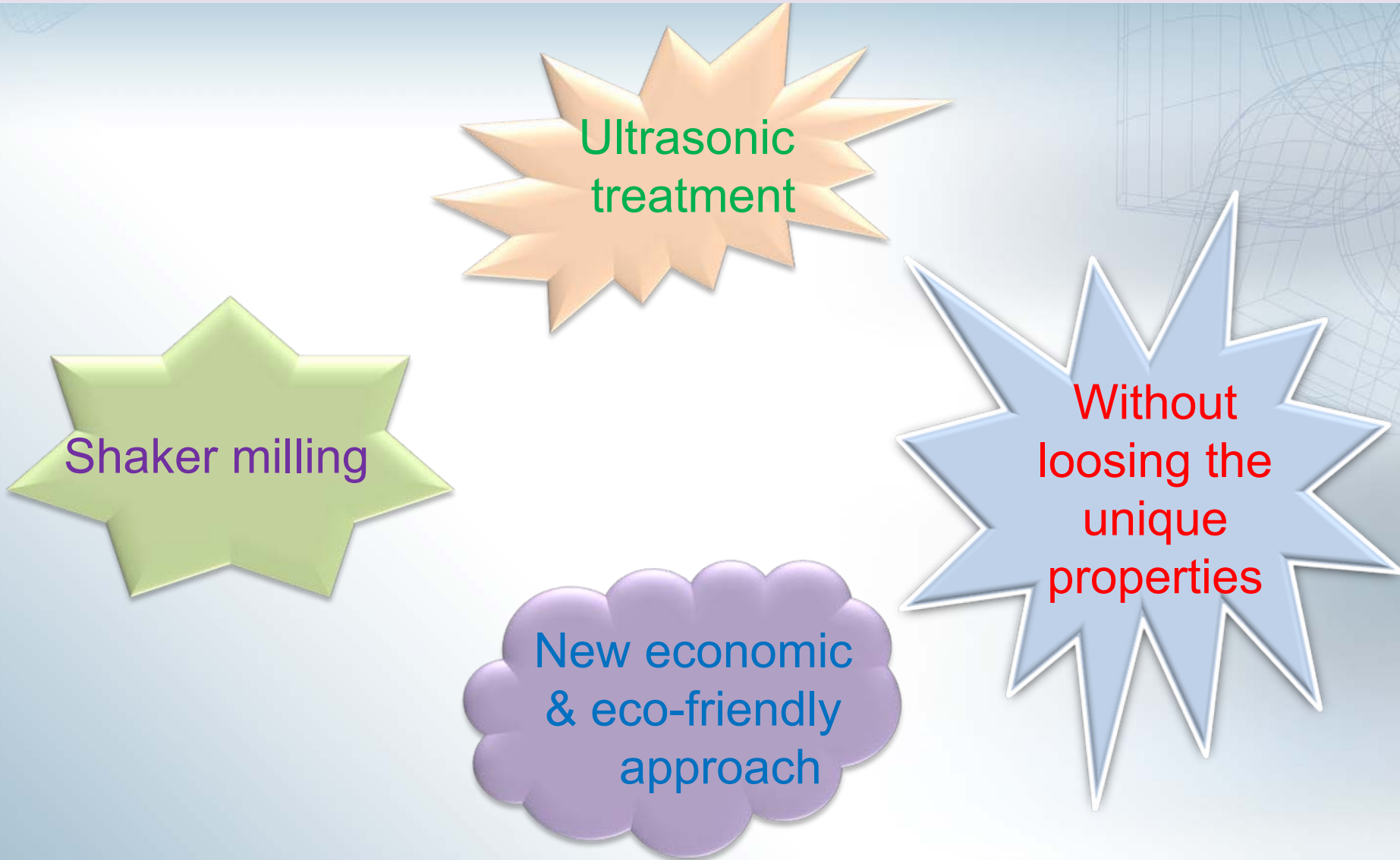
- Antimicrobial component(s) is water insoluble and stemming out from the chemical components of lignin (Afrin et al. 2011)



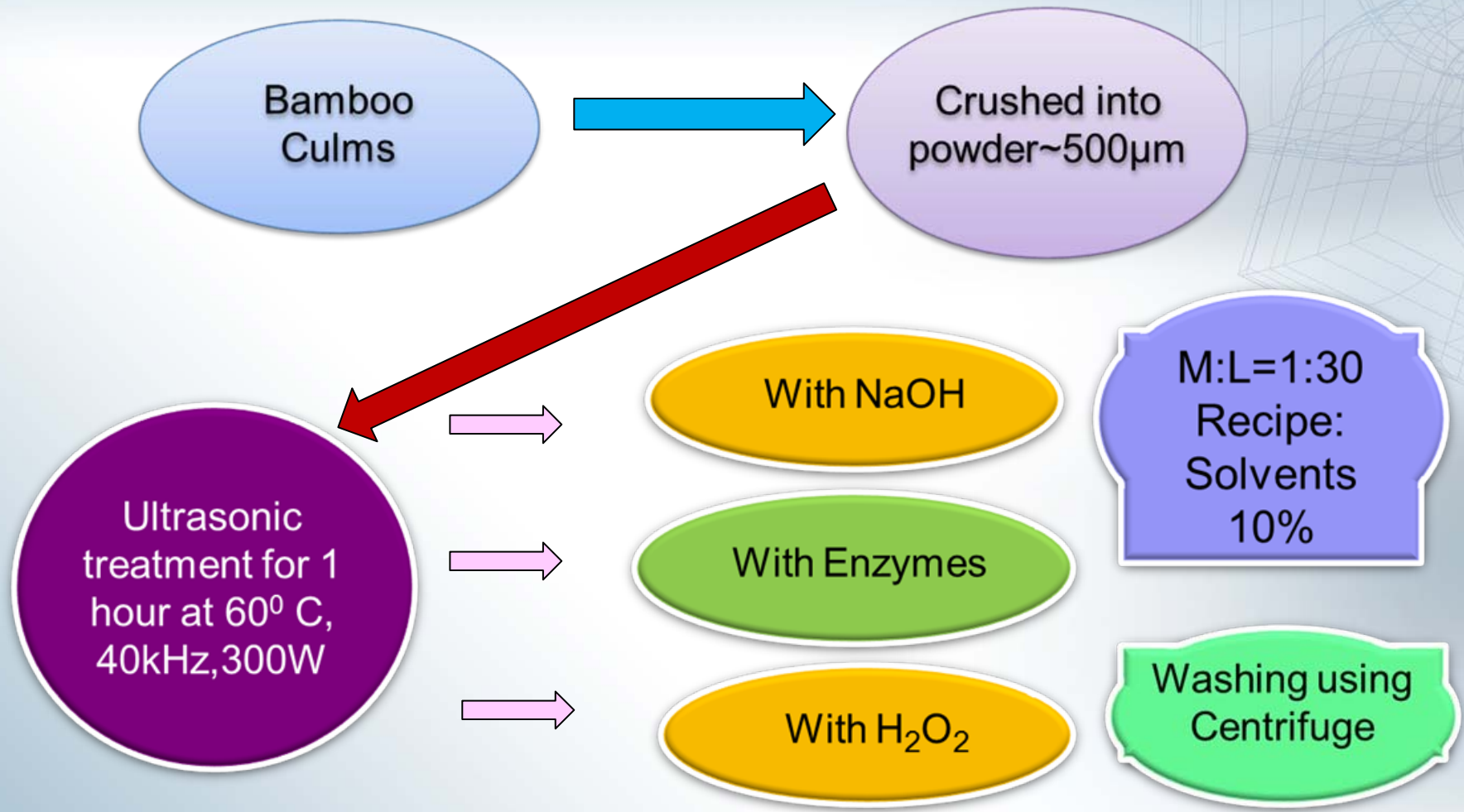
SEM of MWL



Development strategy: manufacturing process

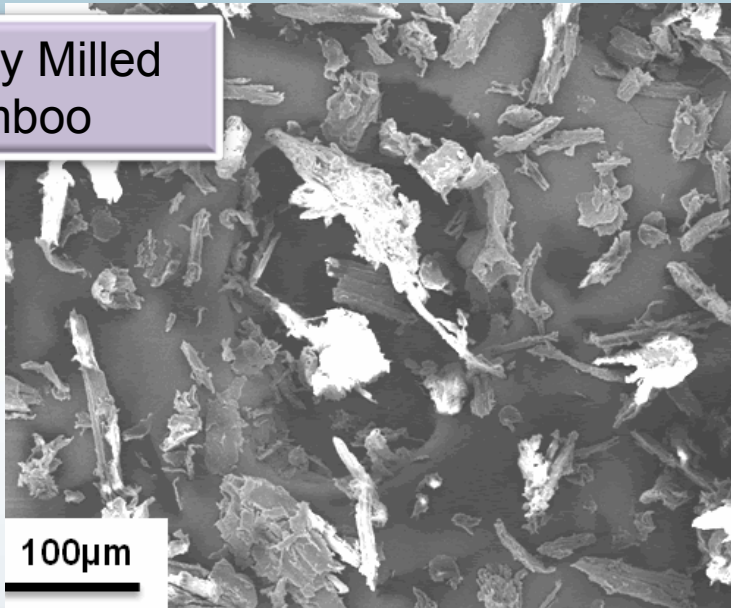


Ultrasonic treatment to process bamboo

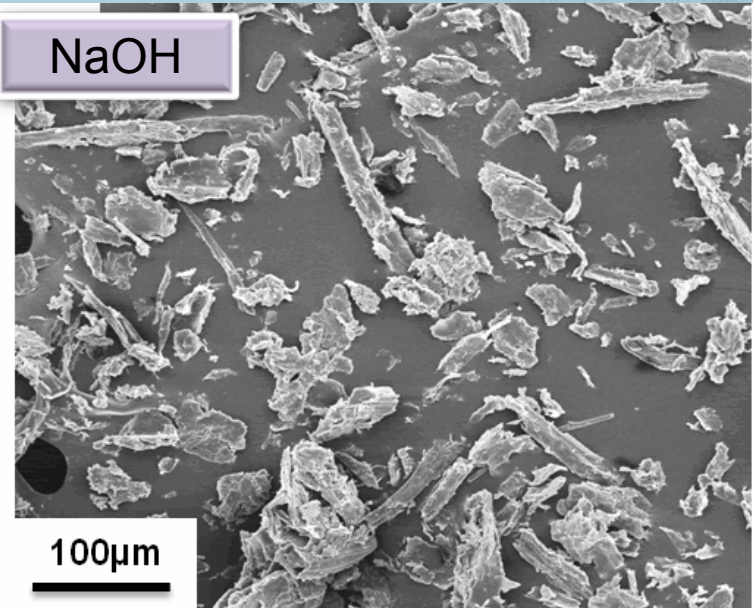


SEM images after ultrasonic treatment

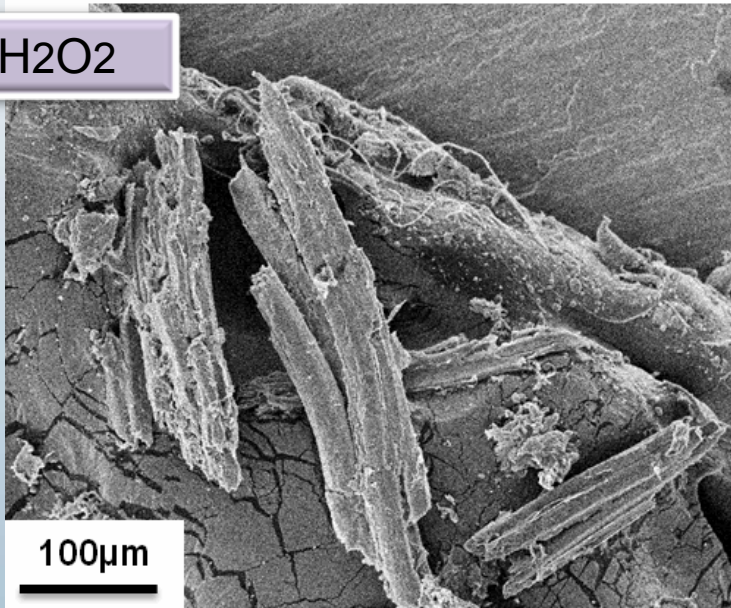
Roughly Milled
bamboo



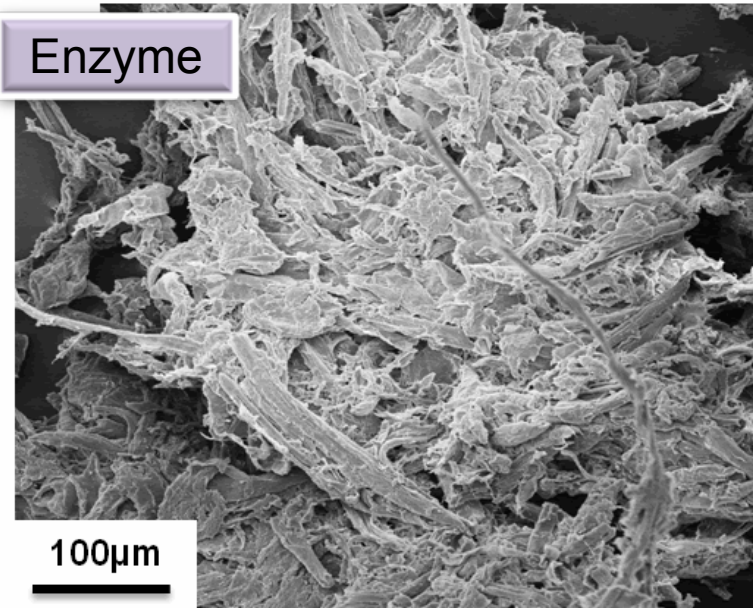
NaOH



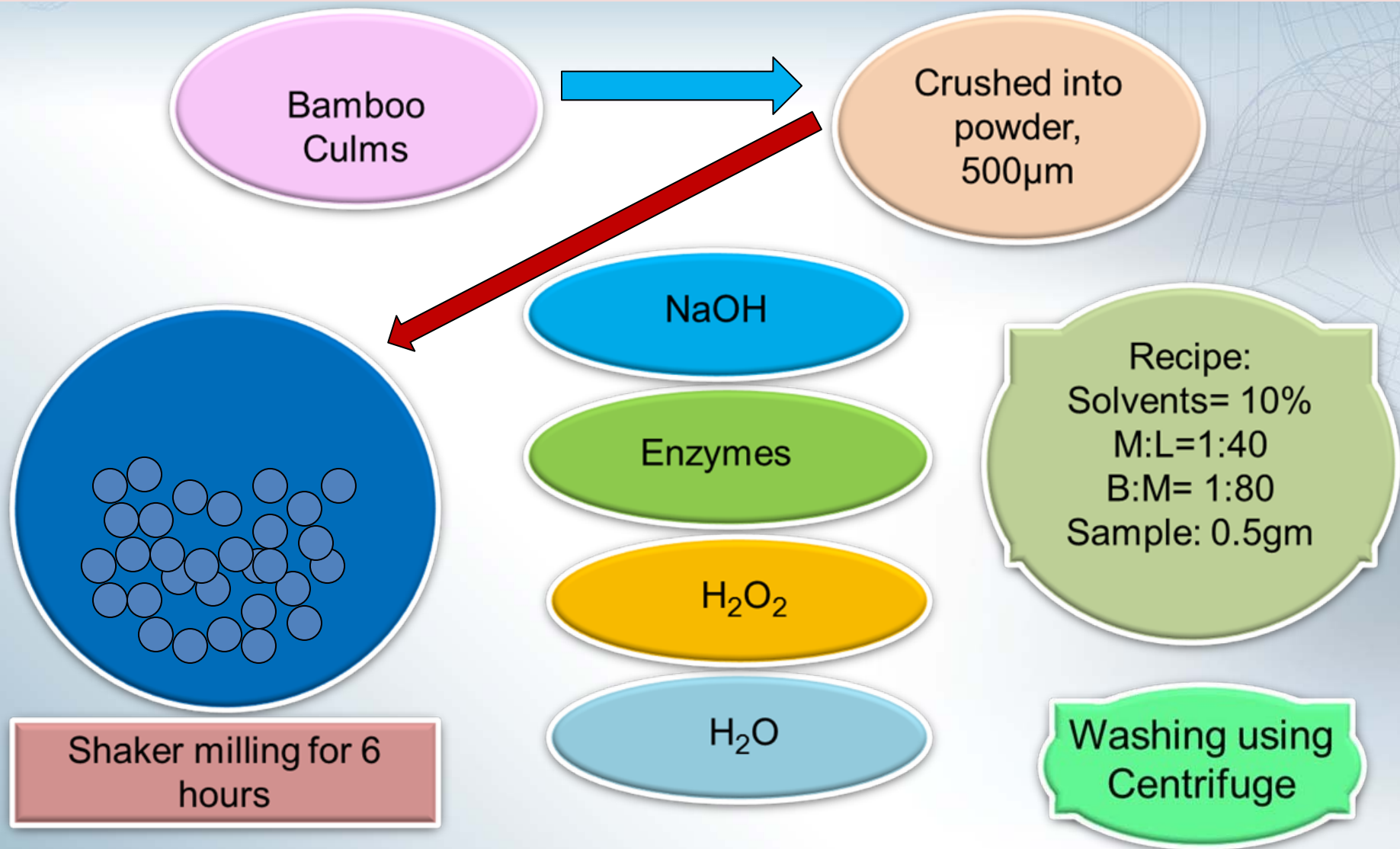
H₂O₂



Enzyme

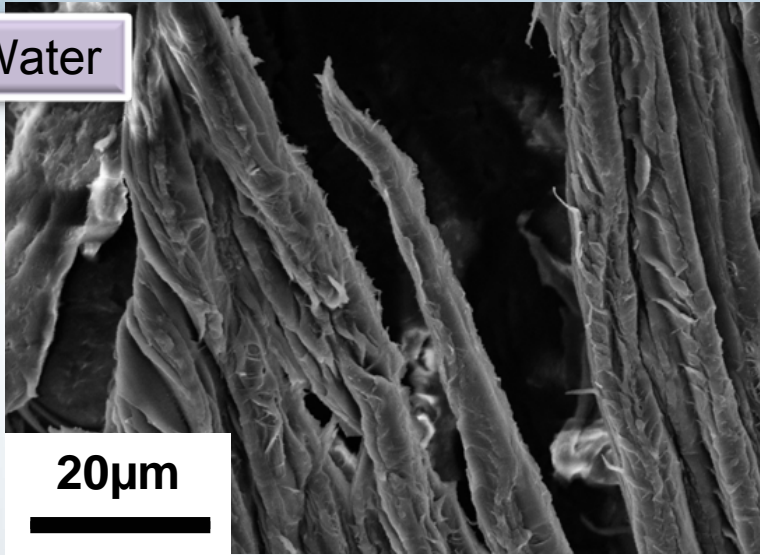


Processing of bamboo: shaker milling

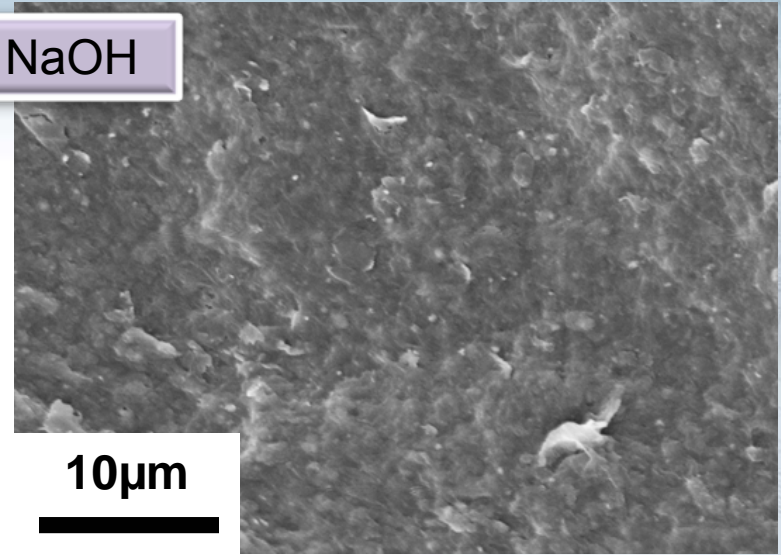


SEM images after shaker milling

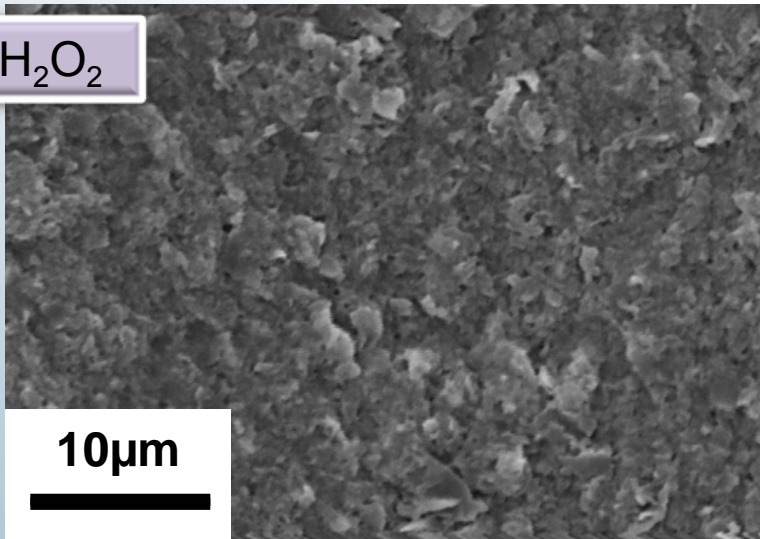
Water



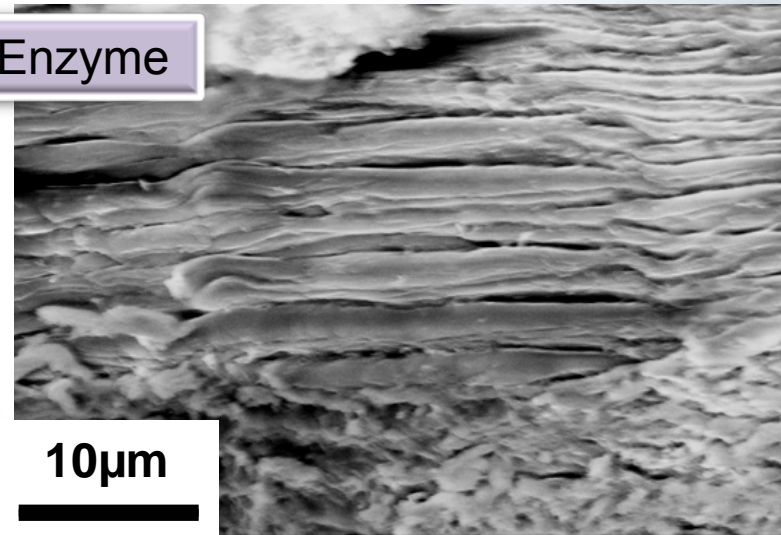
NaOH



H₂O₂

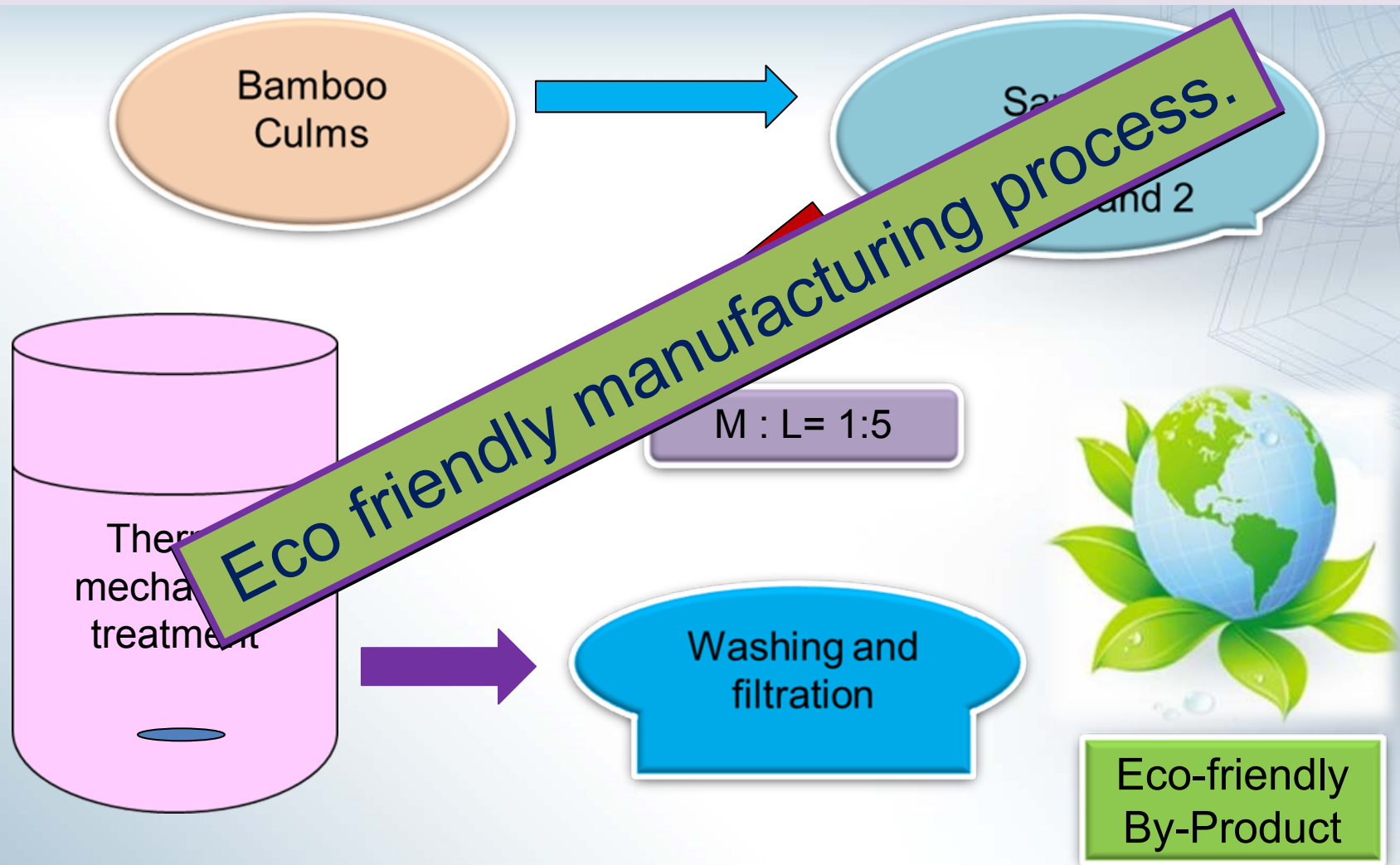


Enzyme

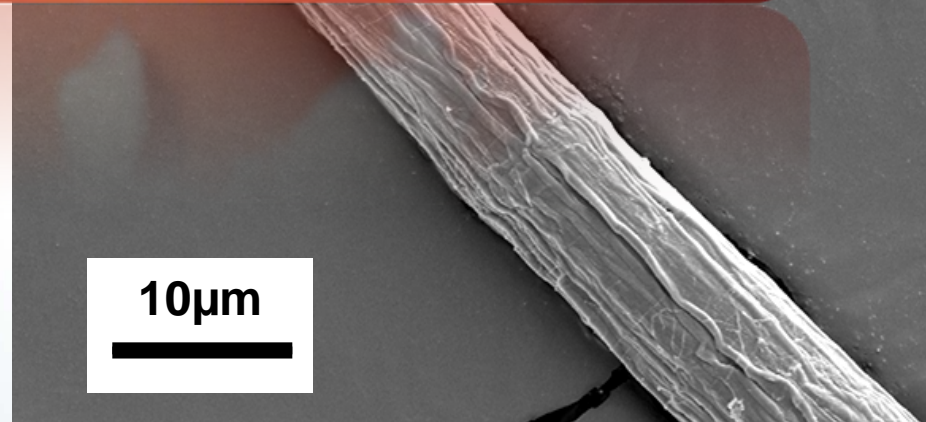
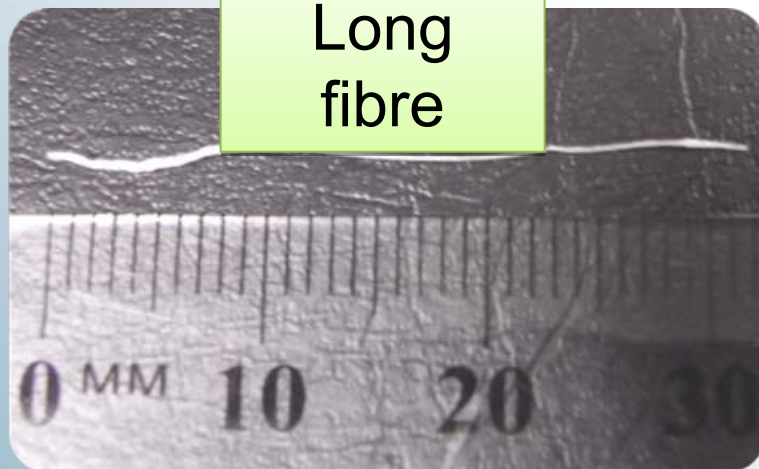
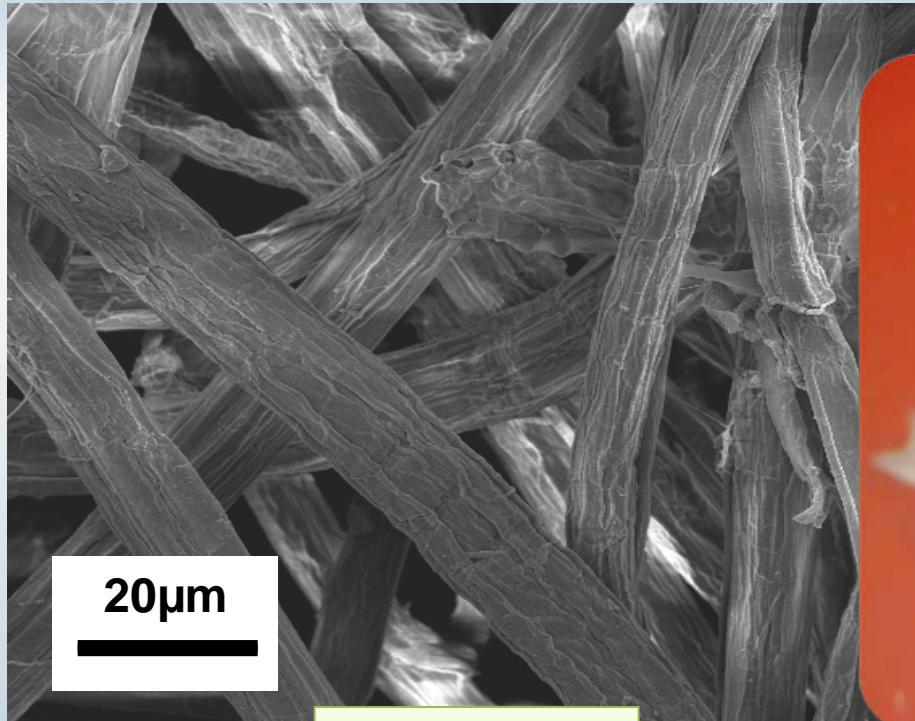


Bamboo fibres can be processed without any chemical aid.

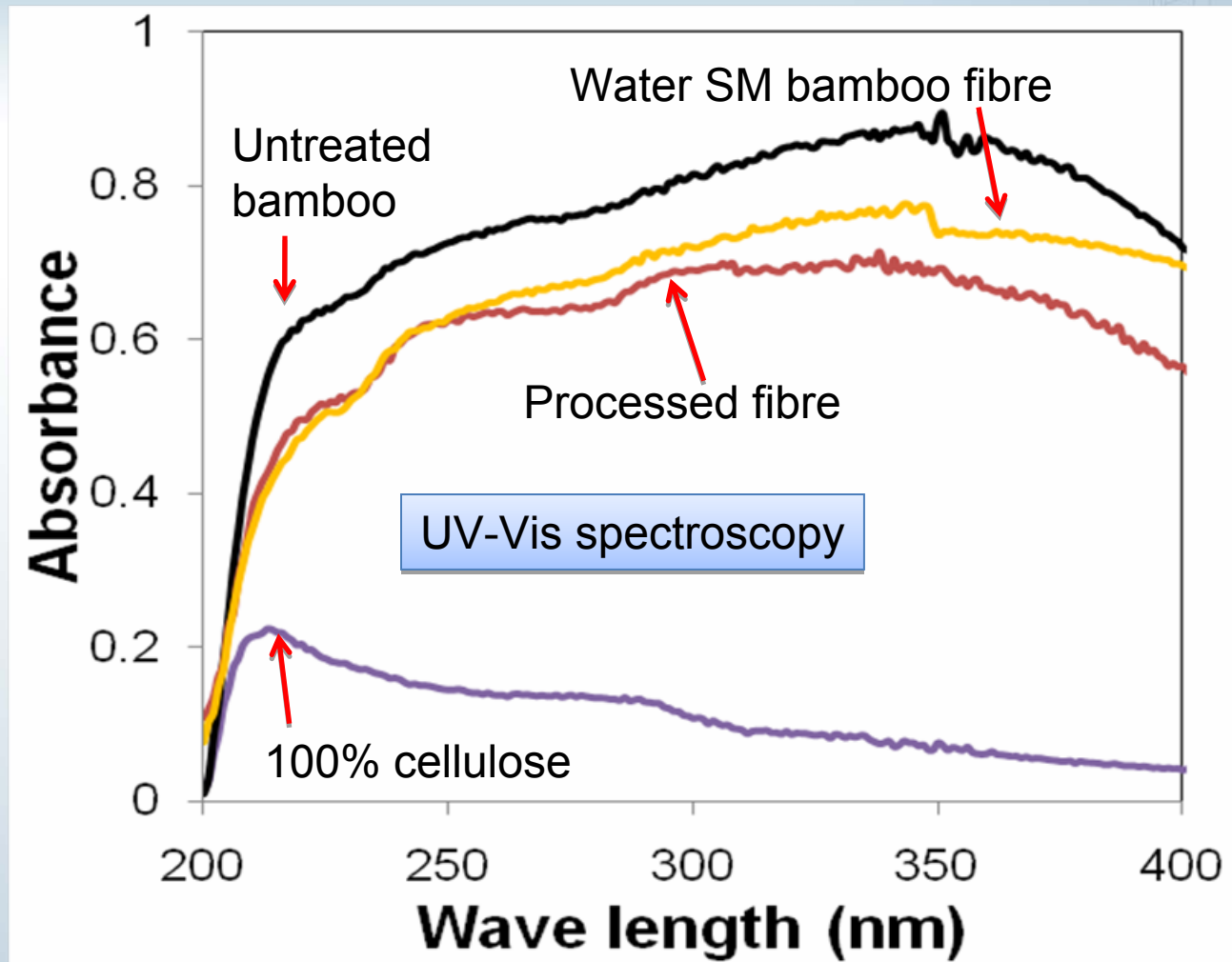
Processing of bamboo



Morphology: processed fibre

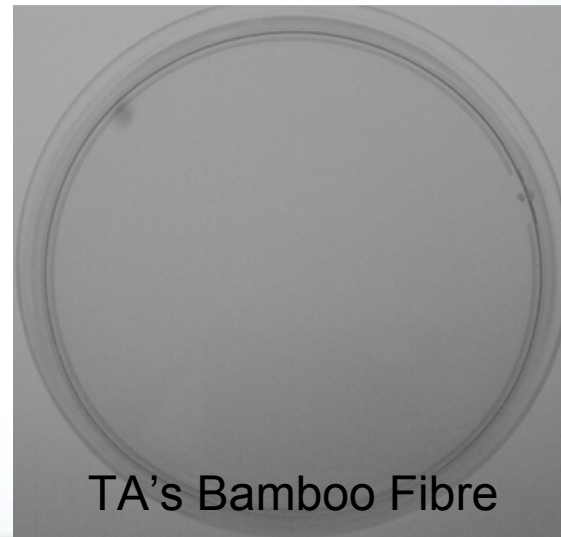
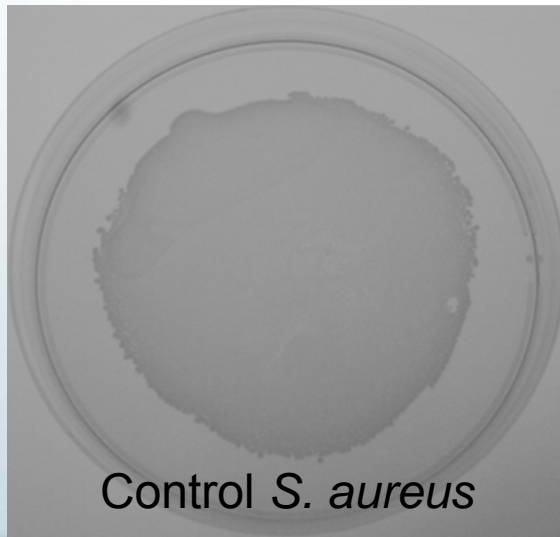
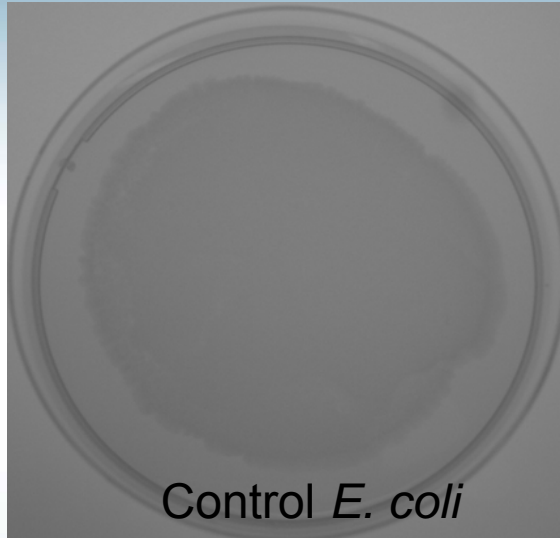


Comparison: UV absorbance



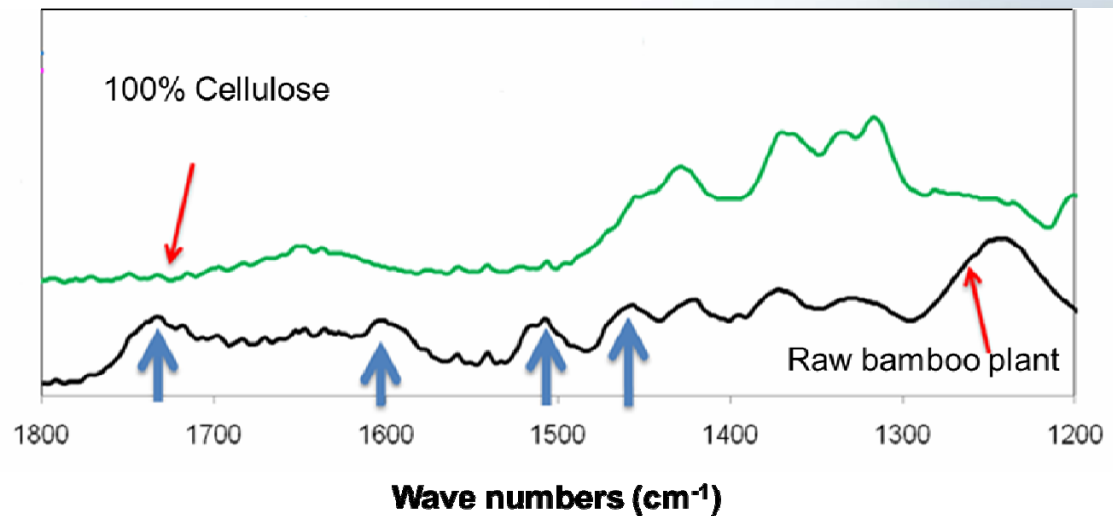
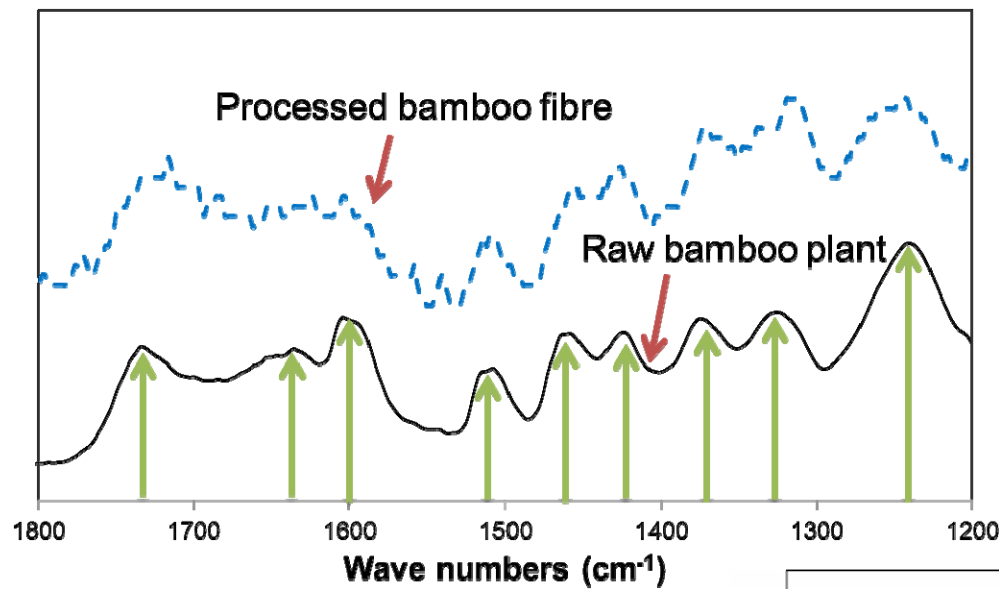
UV blocking ability is preserved after processing.

Antimicrobial property of processed fibre



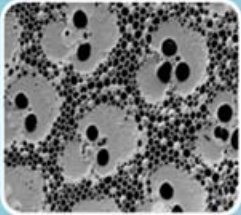
The processed fibres have shown outstanding antibacterial property against fatal and pathogenic bacteria

FT-IR spectroscopy of the processed fibre

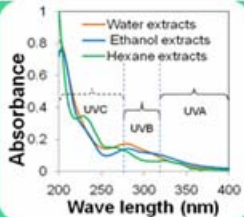


The functional bonds of lignin are retained into the processed fibre

Summary



Bamboo species used for this study is **cellulose-crystalline, micro porous** lignocellulosic natural nano composite with 28% lignin.



In this bamboo species, **more than one** chemical components are responsible for **UV shielding**.



Eco-friendly and **economic** manufacturing processes have been developed **preserving** the unique properties.



Bamboo plant and processed fibres have shown distinctive **antimicrobial activity** but the antimicrobial component(s) is **water insoluble**.



Bamboo plant and processed fibres are **much superior** to cotton, cellulose and commercial bamboo fibres in **UV protection**.

Heading towards...

THE AGE

Bamboo fashion

DEAKINRESEARCH NOVEMBER 2010



It's proven



Former Taranum Afrin is developing a method of processing bamboo fibres into a textile.

936 ABC
Hobart

fibres alter-
fibres
are
sensitive.

claims have been proven scientifically," she said.
Her research could be key to producing clothing material with inherent sun-block qualities.
However, Ms Afrin said a chemical-reliant method of processing bamboo "wasn't friendly to the environment".
"The process we are developing allows us to process the plant into a fibre in an environmentally friendly way while retaining the UV qualities (as well as the wick-

"Bamboo is one of the fastest growing plants in the world," she said.
"It can grow up to one metre overnight and as a result spreads rapidly across large areas. The yield from an acre of bamboo is 10 times greater than that from cotton."
Ms Afrin said pesticides, chemical weeding, insecticides and fungicides were also unnecessary to grow bamboo.
"Unlike cotton" it also needed no irrigation, she said.



702 ABC
Sydney

of the fastest growing plants in the world and grows to its maximum height in about three months," she said.
"It can grow up to one metre overnight."
"The yield from an acre of bamboo is 10 times greater than that from cotton."
"It also does not need pesticides, chemical weeding, insecticides and fungicide to grow."
Ms Afrin is already receiving interest from textile firms around the world.

Acknowledgements

- Academic Supervisors
- Technical Staffs at IFM
- Dr. Keith Millington at CSIRO
- Members of The Textile Group



BAMBOO SOCIETY
of AUSTRALIA

ALJANT2VVA to



Australian Government



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Thank You!