DEAKIN UNIVERSITY AUSTRALIA

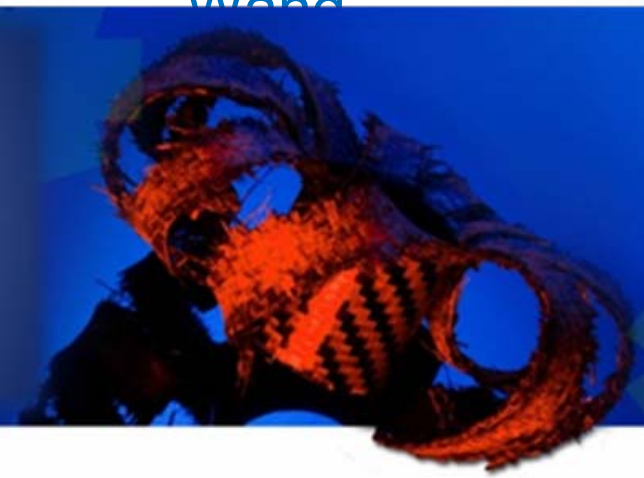
Novel Approaches to Process Bamboo Plants into Fibres and their UV-blocking Property

Tarannum Afrin
PhD Candidate

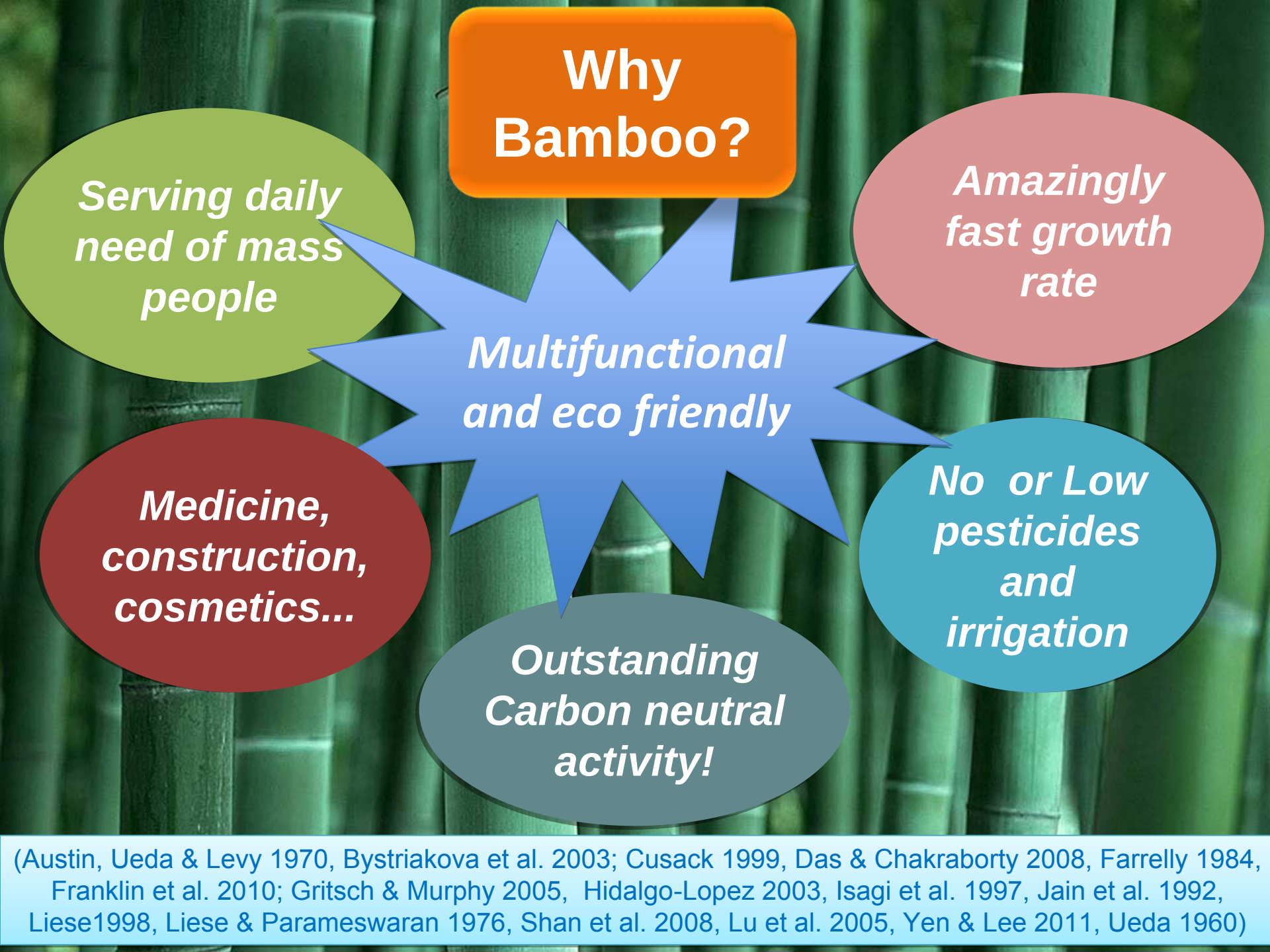
Supervisors:
Asst. Prof. Takuya Tsuzuki, Dr. Rupinder Kanwar, Prof. Xungai Wang

INSTITUTE FOR FRONTIER MATERIALS

REAL WORLD SOLUTIONS

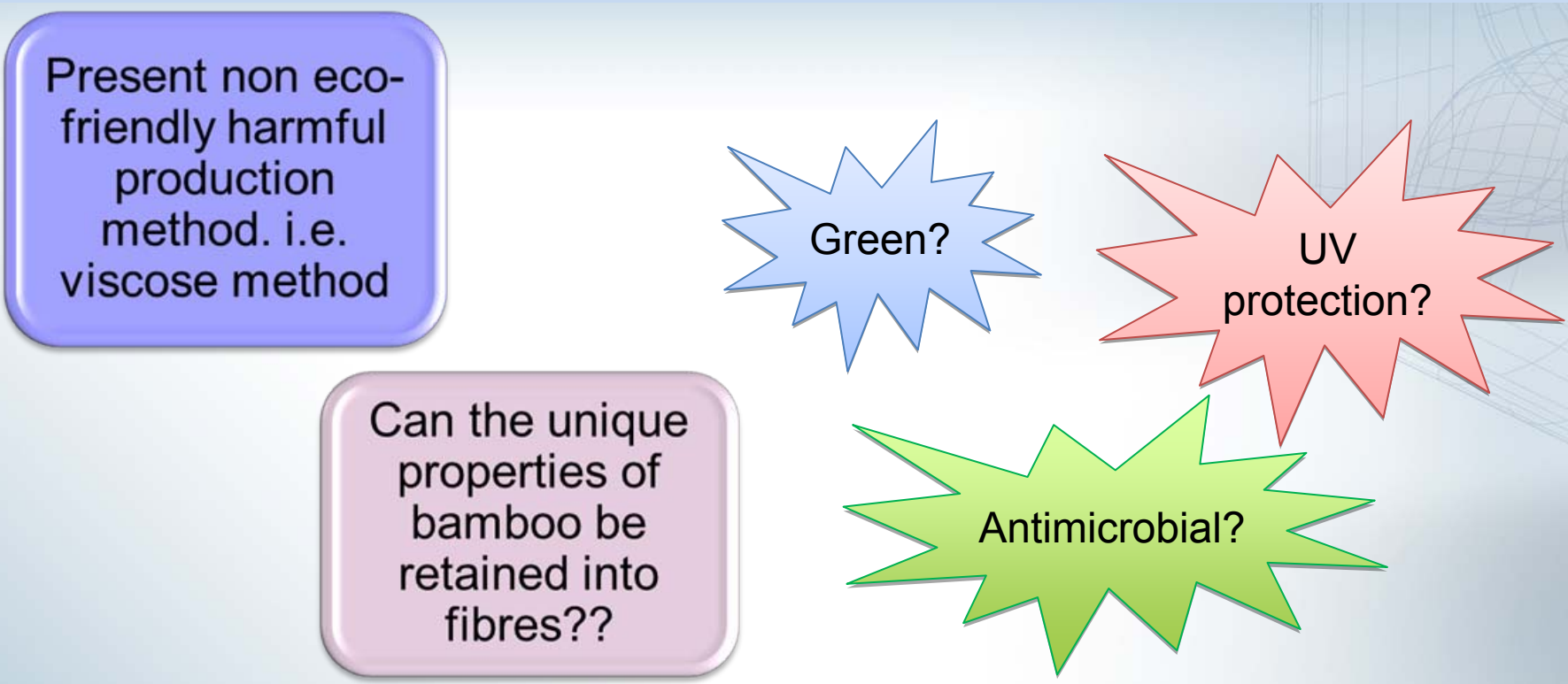


DEAKIN UNIVERSITY AUSTRALIA



(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, Liese1998, Liese & Parameswaran 1976, Shan et al. 2008, Lu et al. 2005, Yen & Lee 2011, Ueda 1960)

Motivation: myth of bamboo textiles



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.

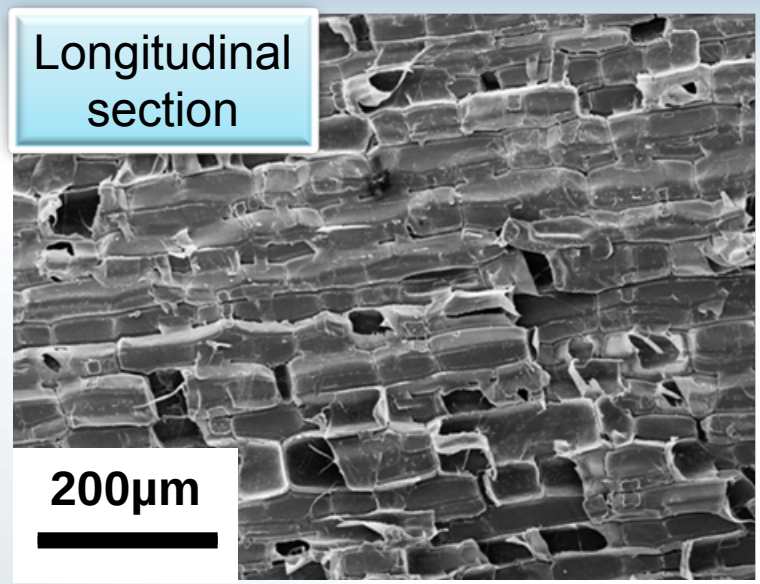
Australian grown: *Phyllostachys pubescens*

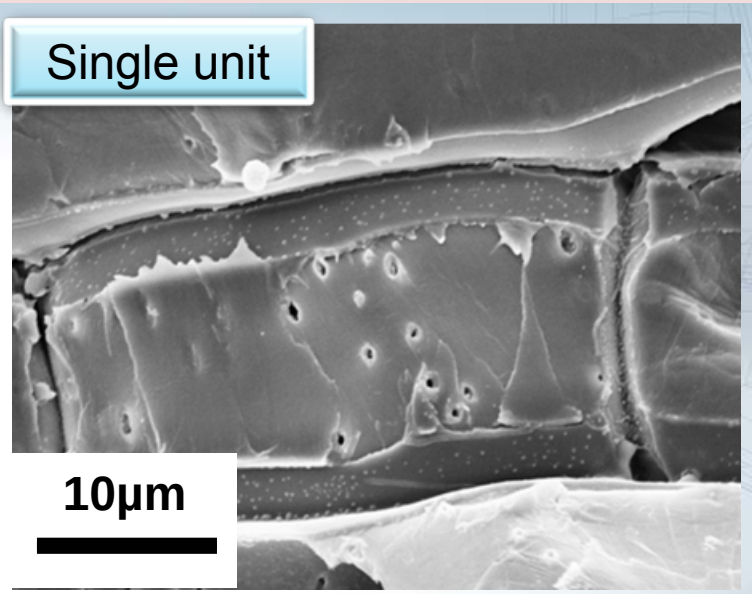
Crystalline structures : X-ray Diffraction (XRD).

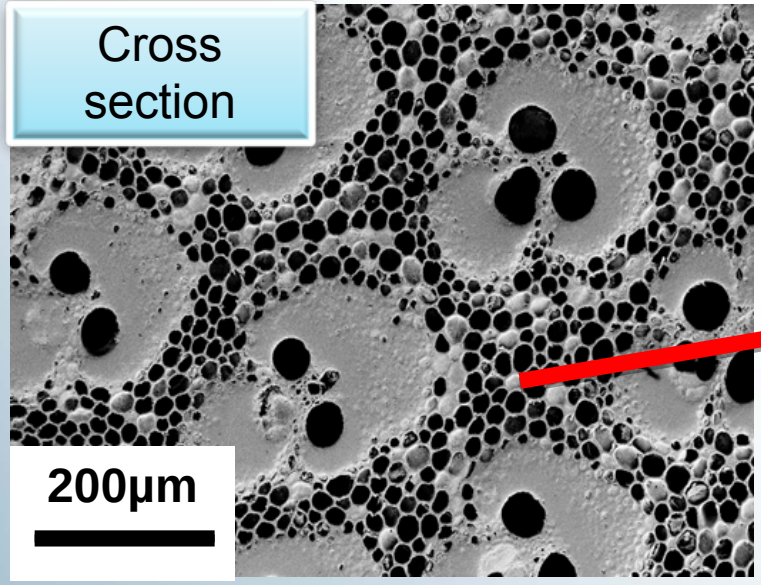
Chemical constituents analysis: Chinese standard: GB5889-86.

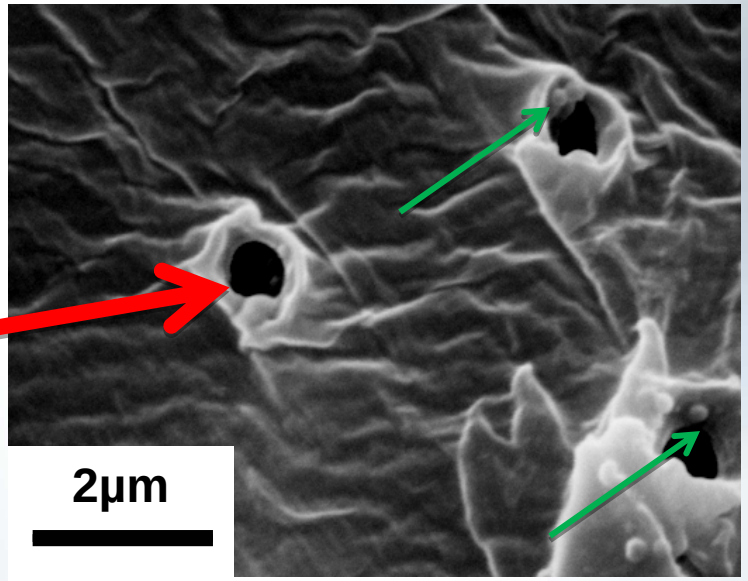
Chemical bonds analysis: Fourier Transform Infrared Spectroscopy (FT-IR).

Morphology of raw bamboo (under SEM)

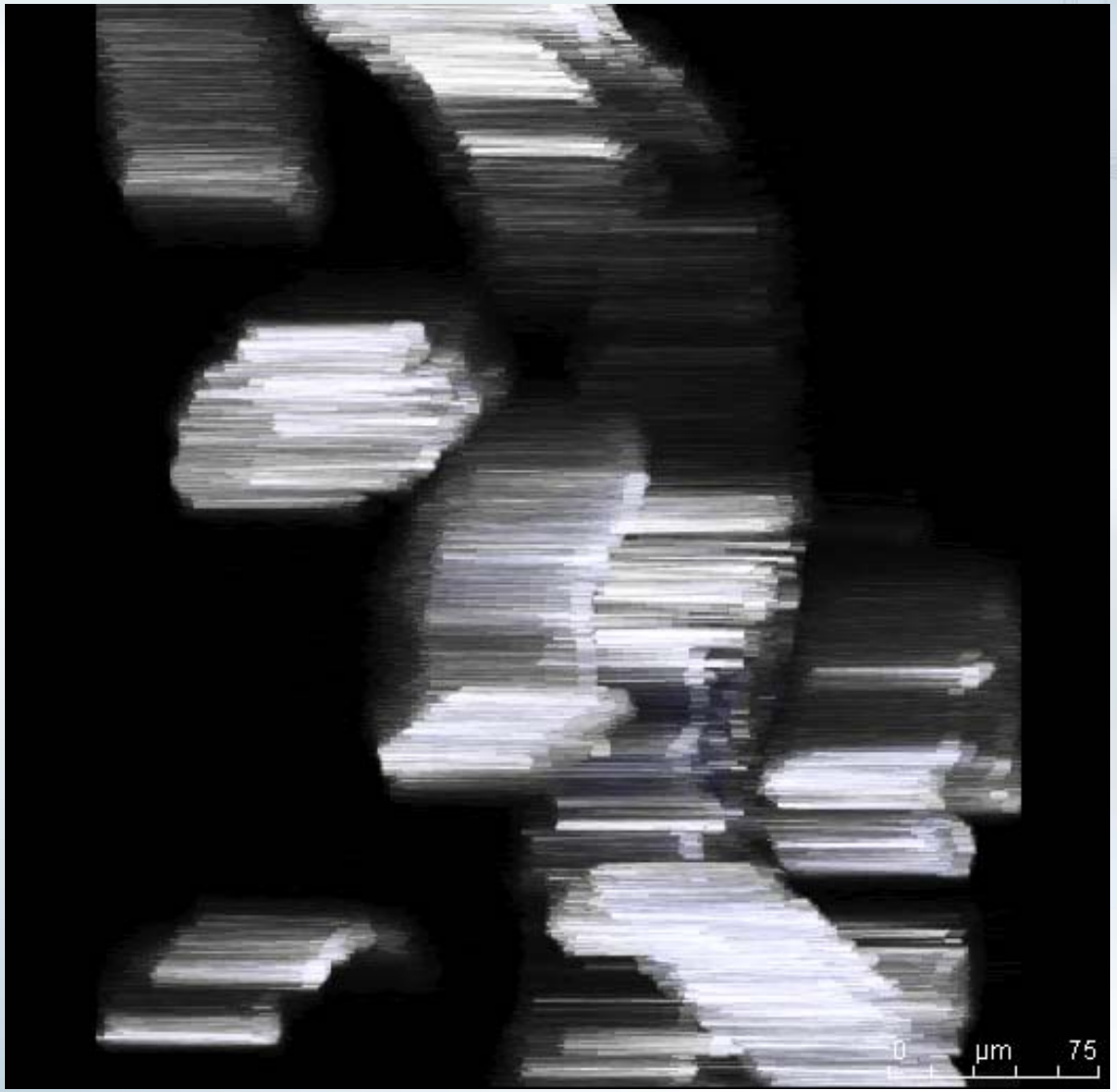




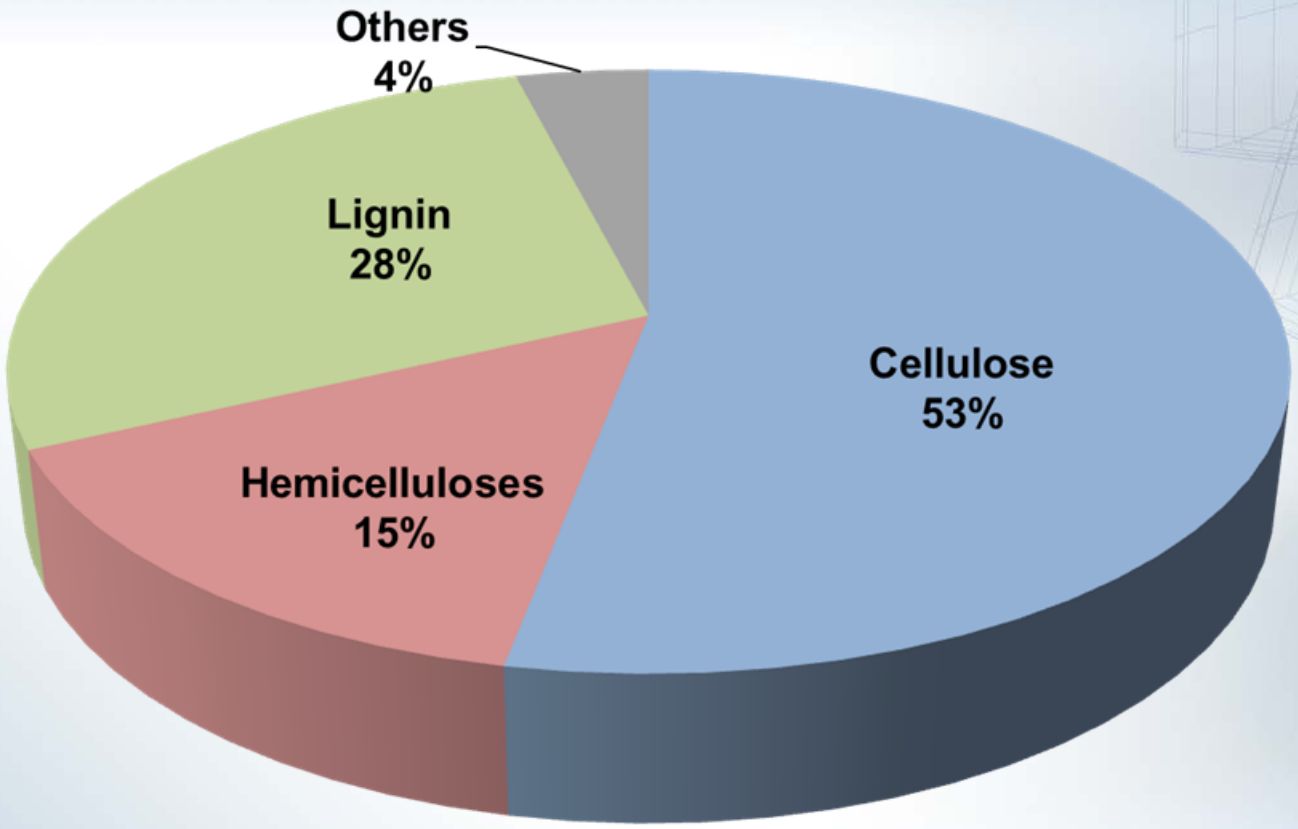




Under confocal microscope

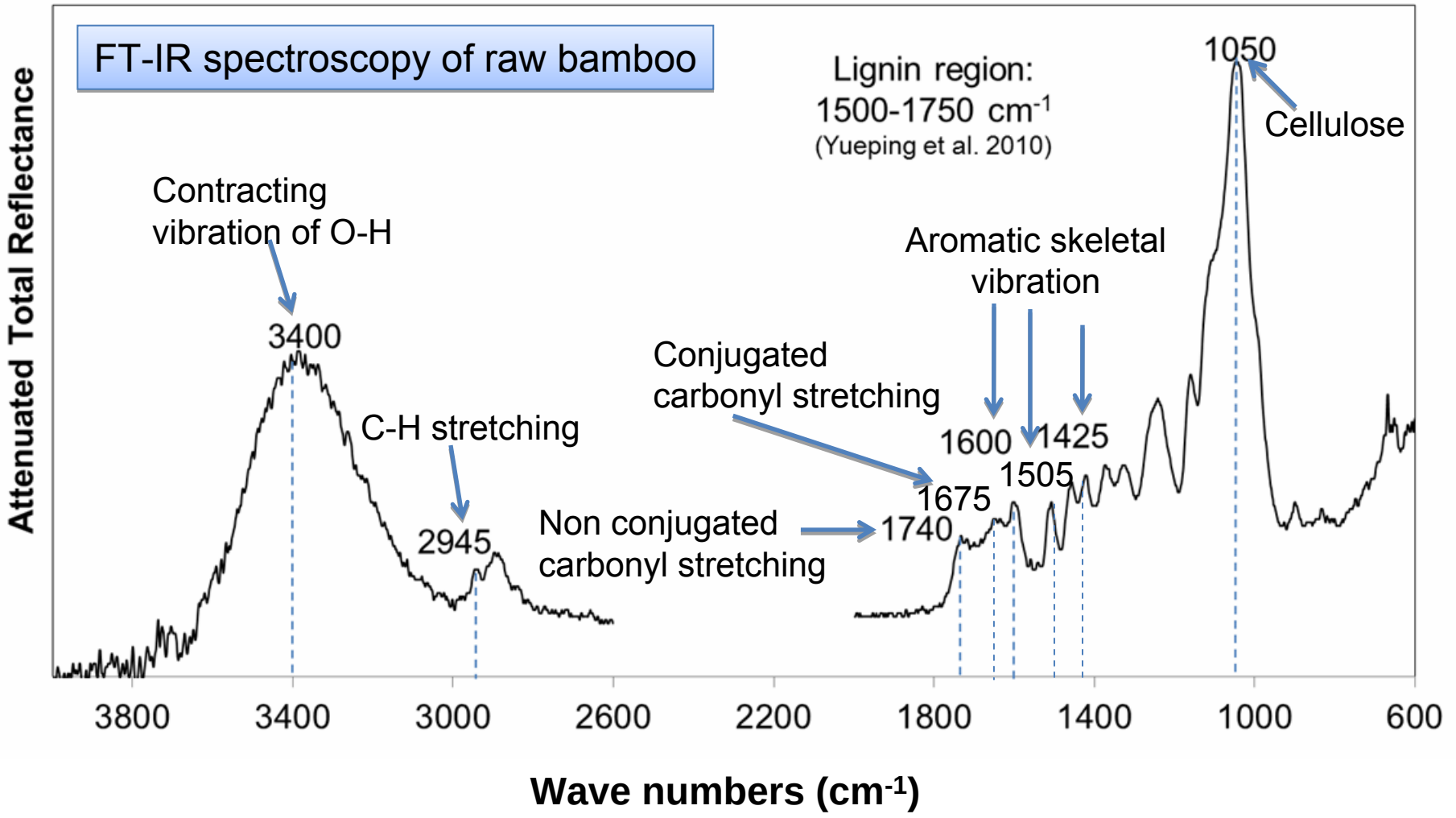


Chemical constituents analysis

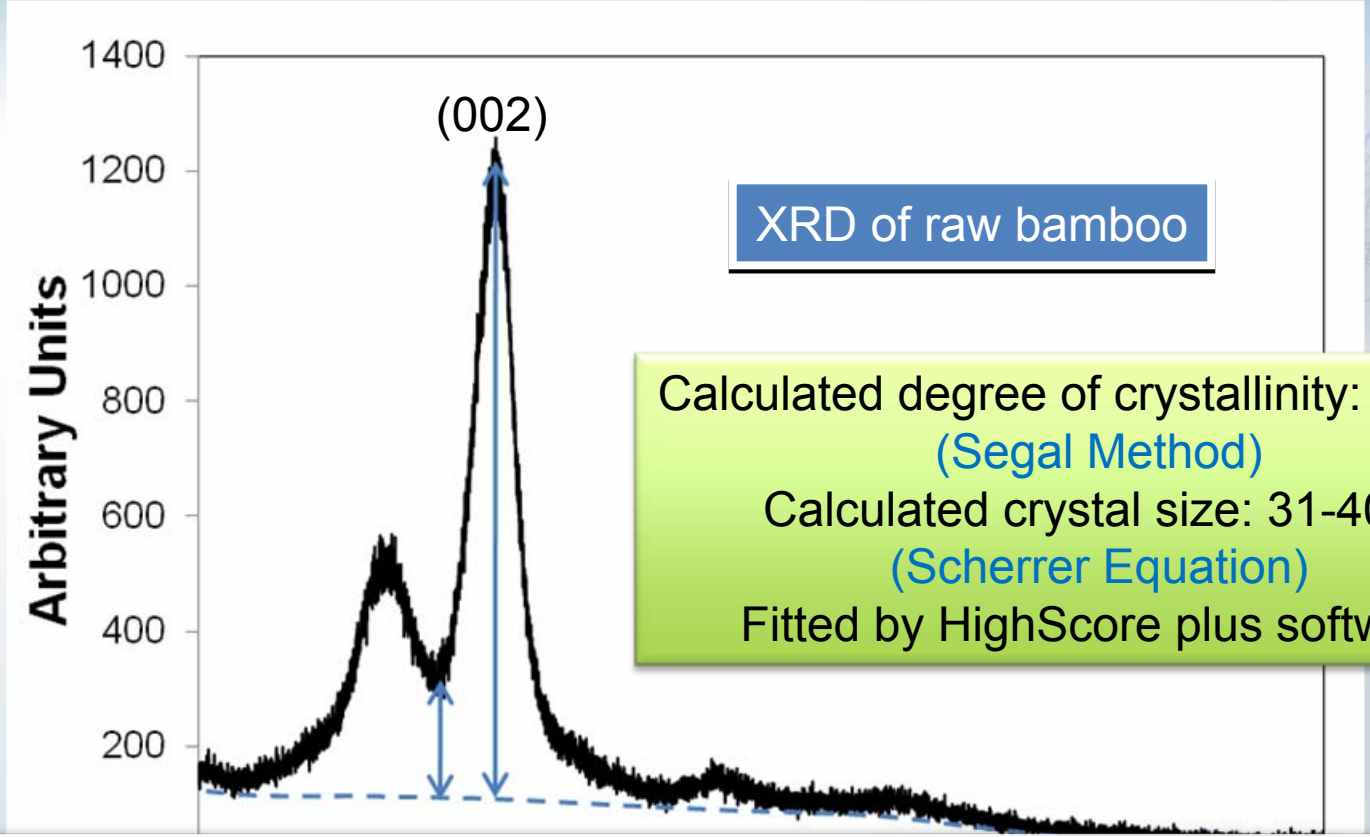


According to Standard:
GB5889-86

Functional chemical bonds in raw bamboo



Crystalline structure of raw bamboo



XRD 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 ($2\theta=22.6^{o}$) and I_{am} the peak intensity of amorphous phase ($2\theta=19^{o}$).

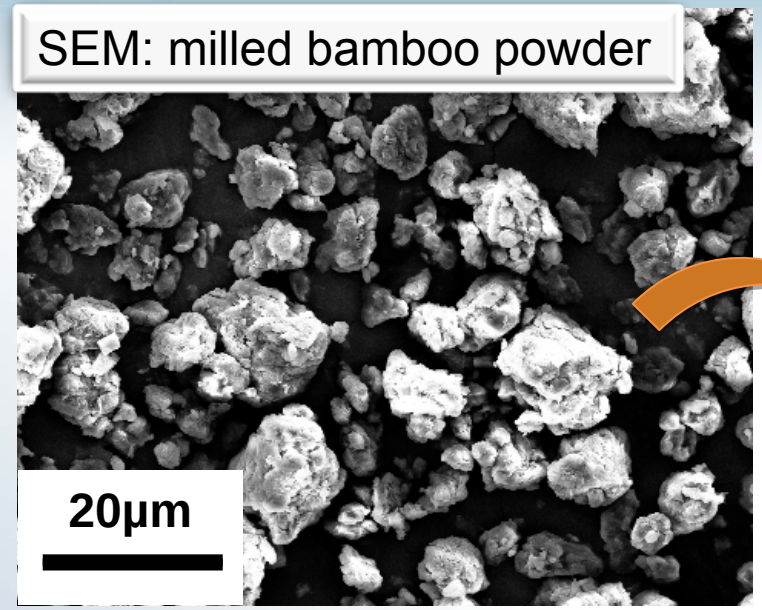
Origin of the UV shielding Characteristic of Raw Bamboo

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

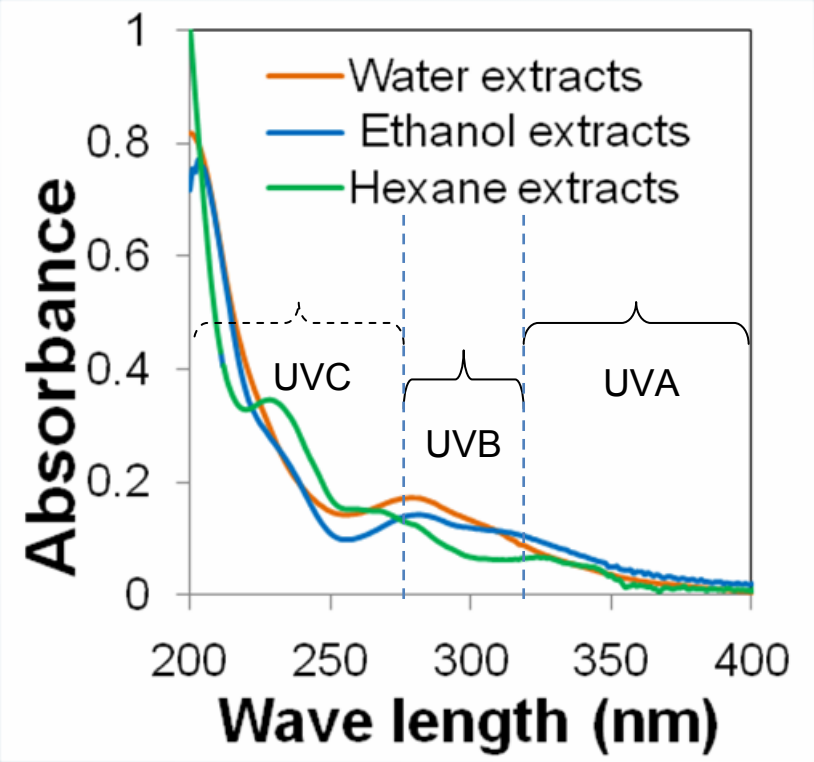
Milled bamboo 10 gram
+
Solvents

Filtration

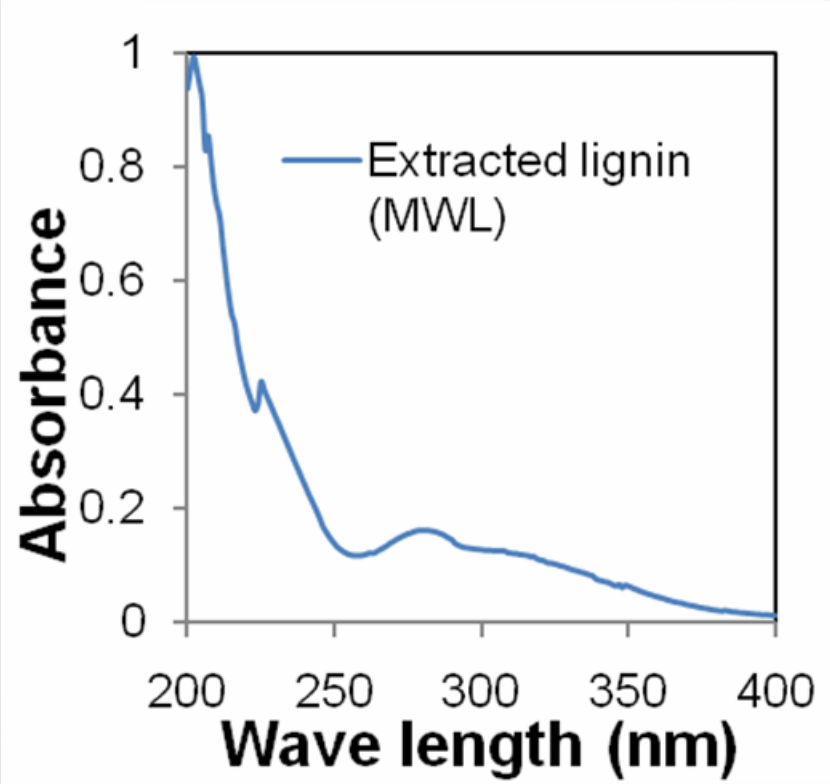
Centrifuged filtrate

Transparent solution

UV absorbance of raw bamboo extracts

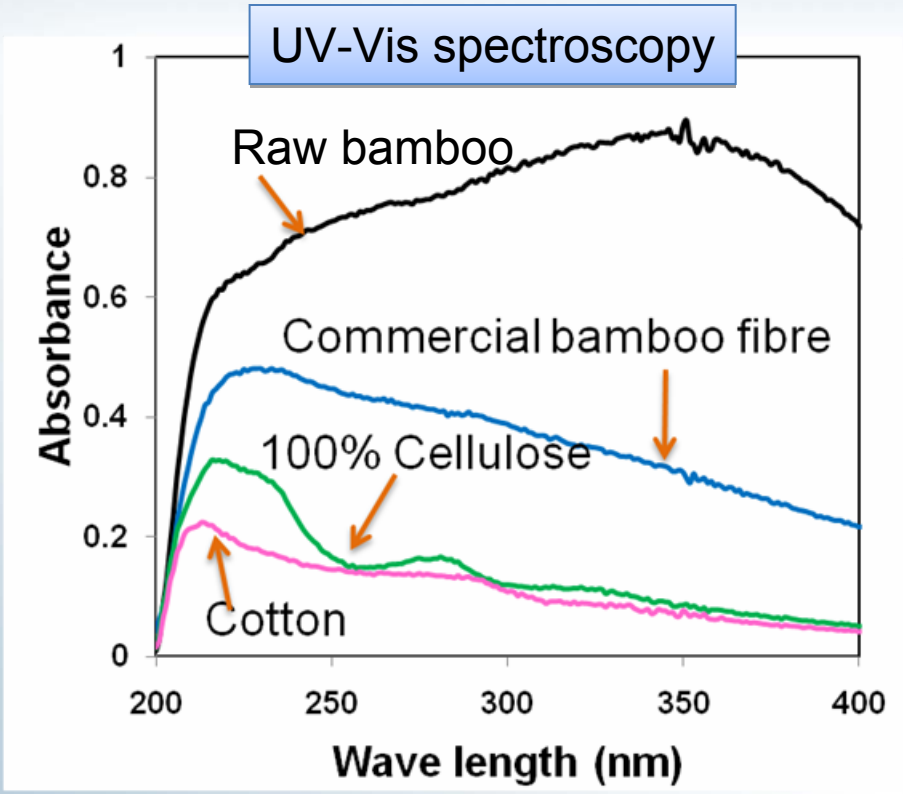


UVA: 315-400 nm
UVB: 280-315 nm
UVC: 100-280 nm

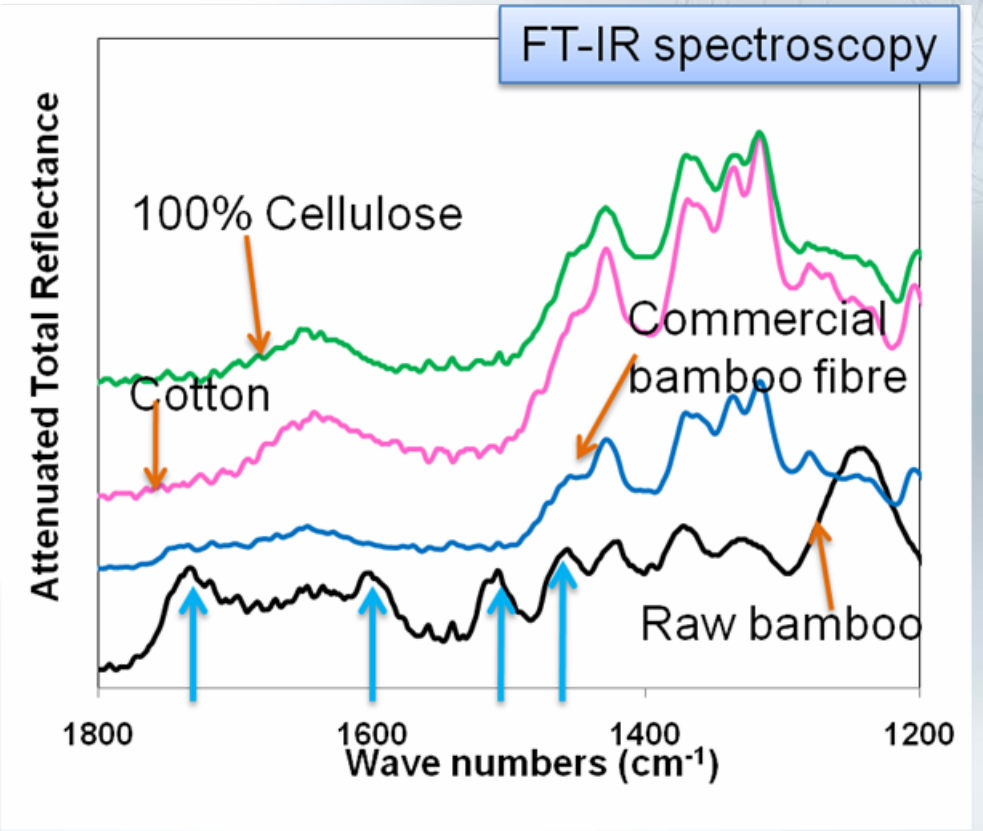


- More than one UV responsible component (Afrin et al., 2011).

Relation between UV absorbance and chemical bonds of lignin



Solid state



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

Origin of the Antimicrobial Property of Raw Bamboo

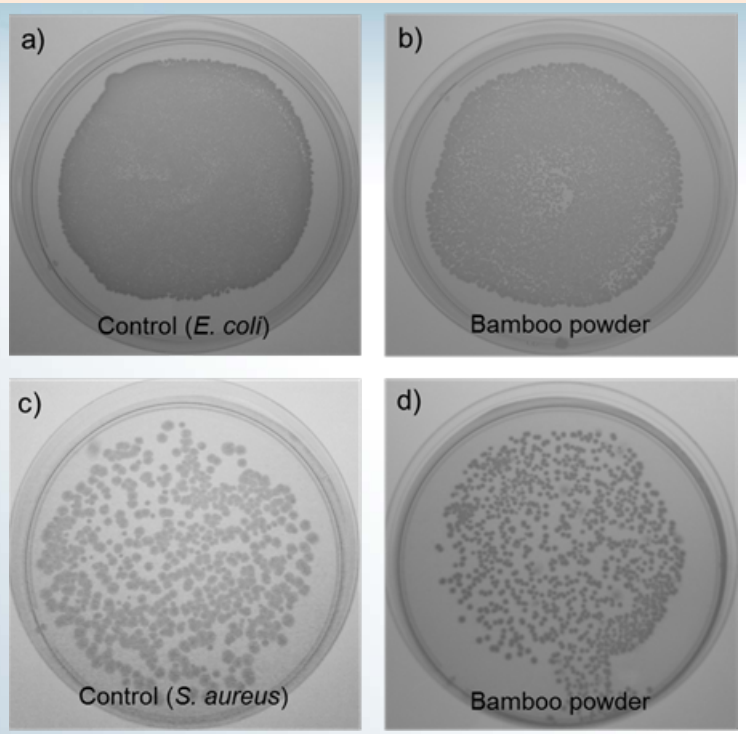
Challenge Bacteria: Gram negative bacteria, ***Escherichia coli*** (*E. coli*): ATCC 25922 and gram positive bacteria ***Staphylococcus aureus*** (*S. aureus*): ATCC 25923

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

Samples:

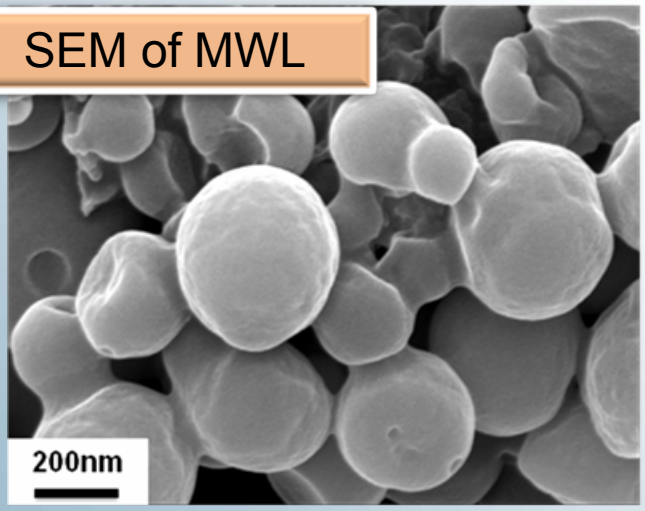
- Bamboo Powder
- Bamboo extracts in water.
- Bamboo extracts in 90% aqueous dioxane (MWL). (after extraction dioxane is evaporated)
- Bamboo extracts in DMSO

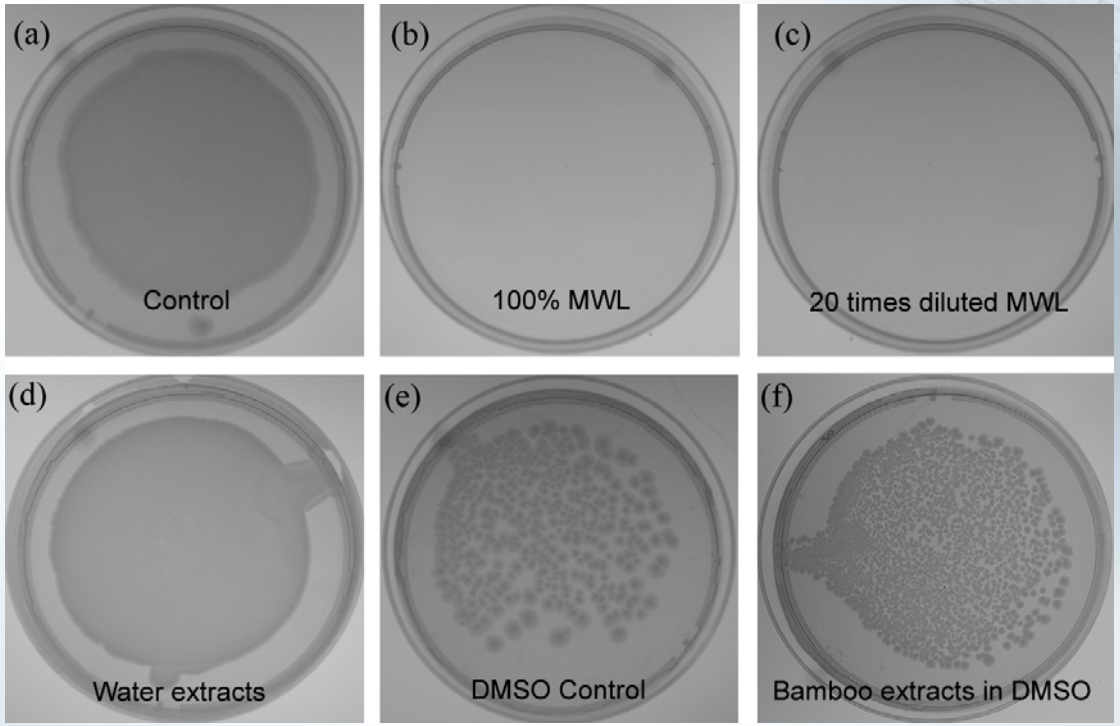
Antimicrobial test results



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

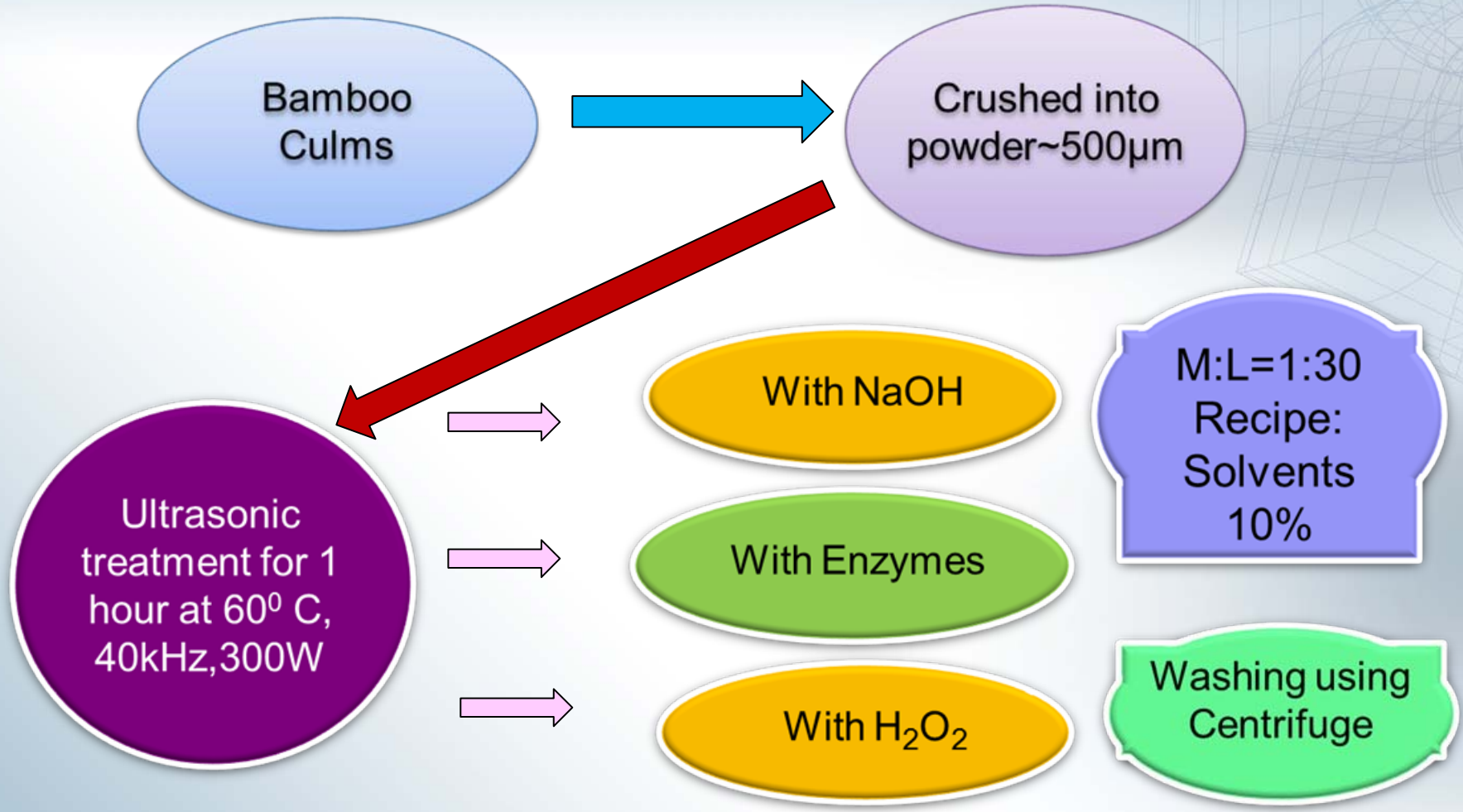
SEM of MWL



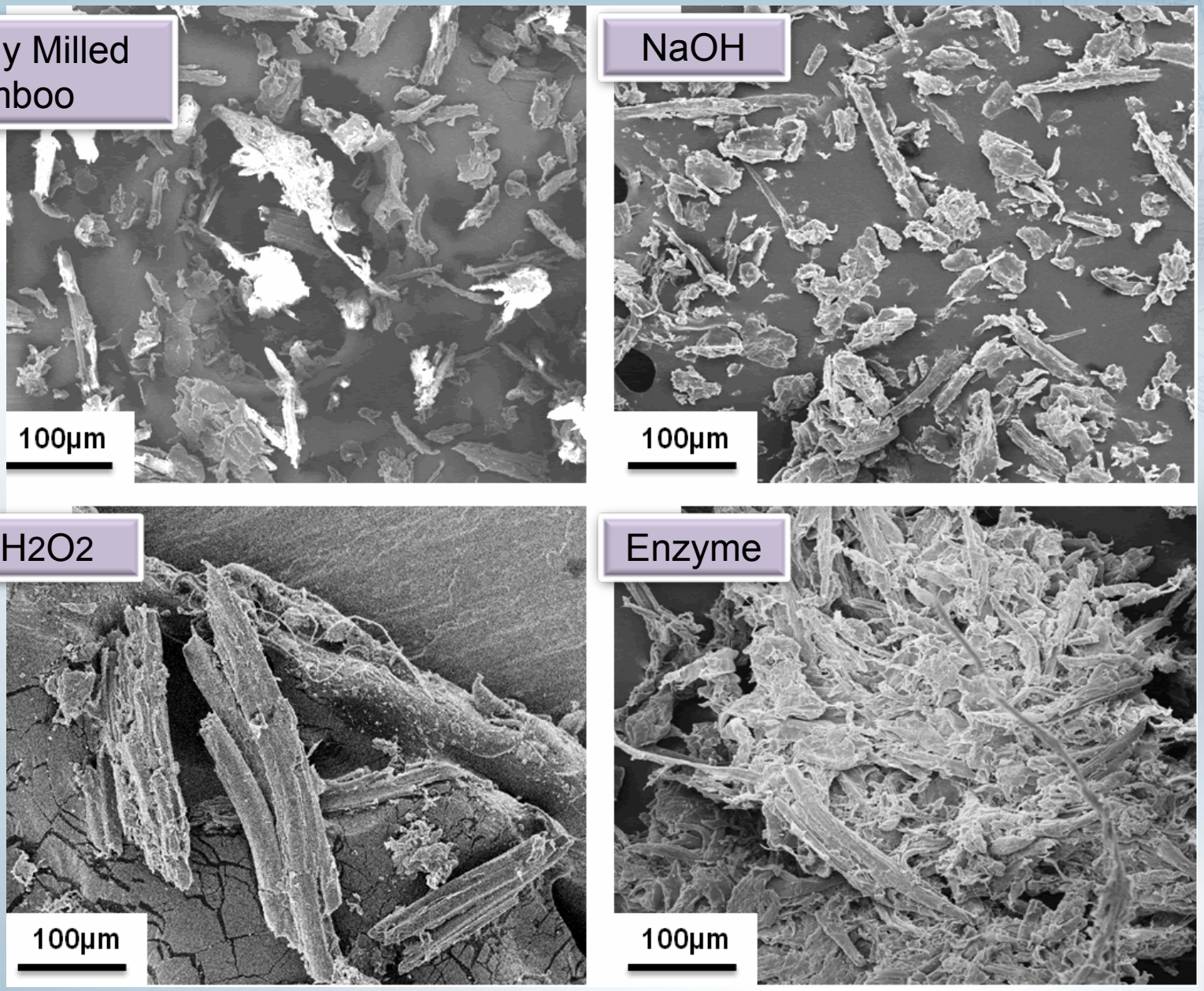


Development strategy: manufacturing process

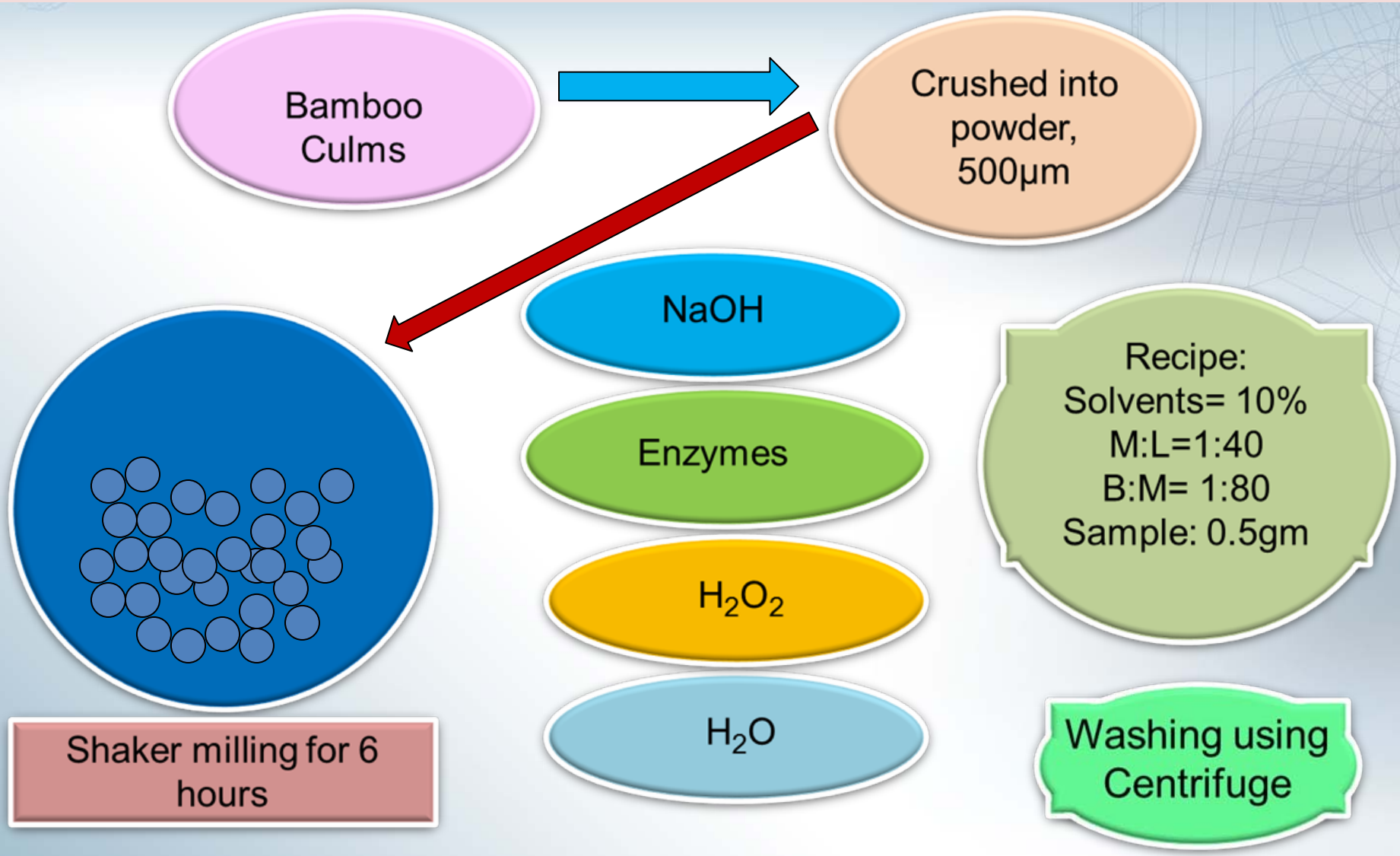
Ultrasonic treatment to process bamboo



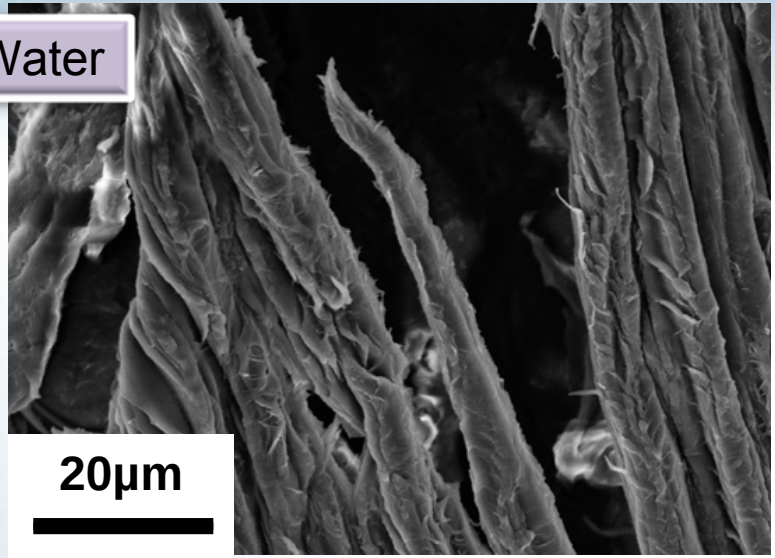
SEM images after ultrasonic treatment

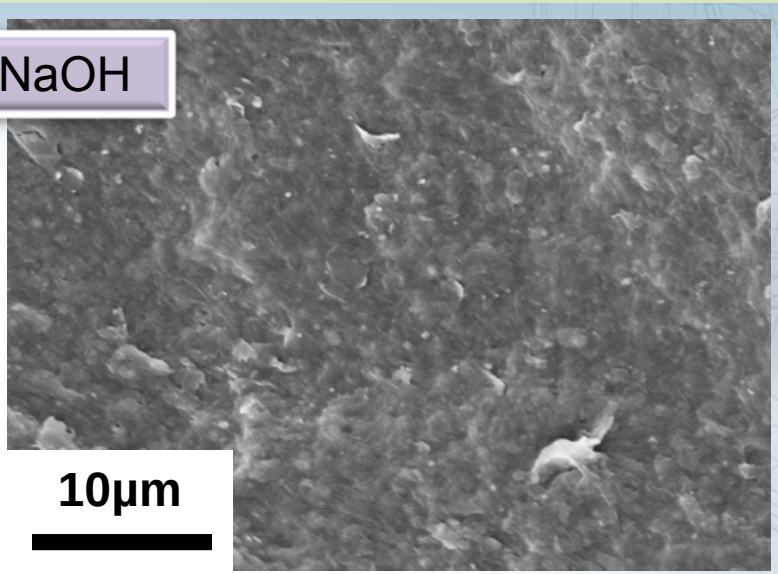


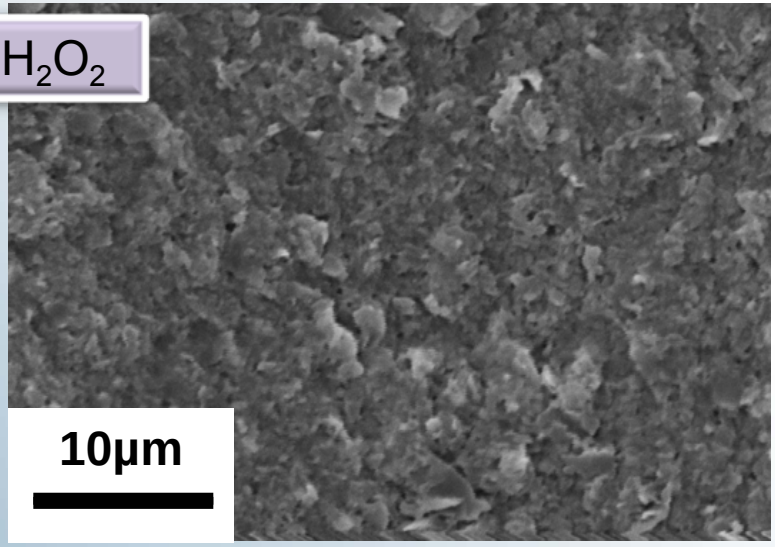
Processing of bamboo: shaker milling

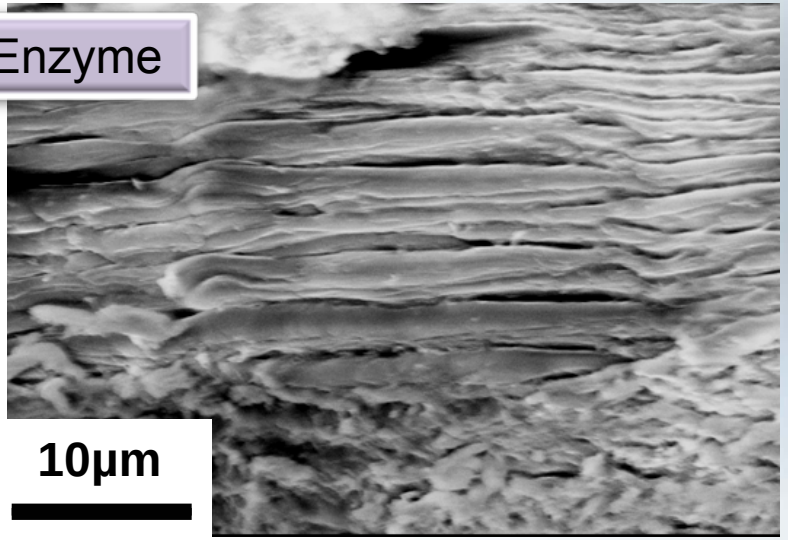


SEM images after shaker milling



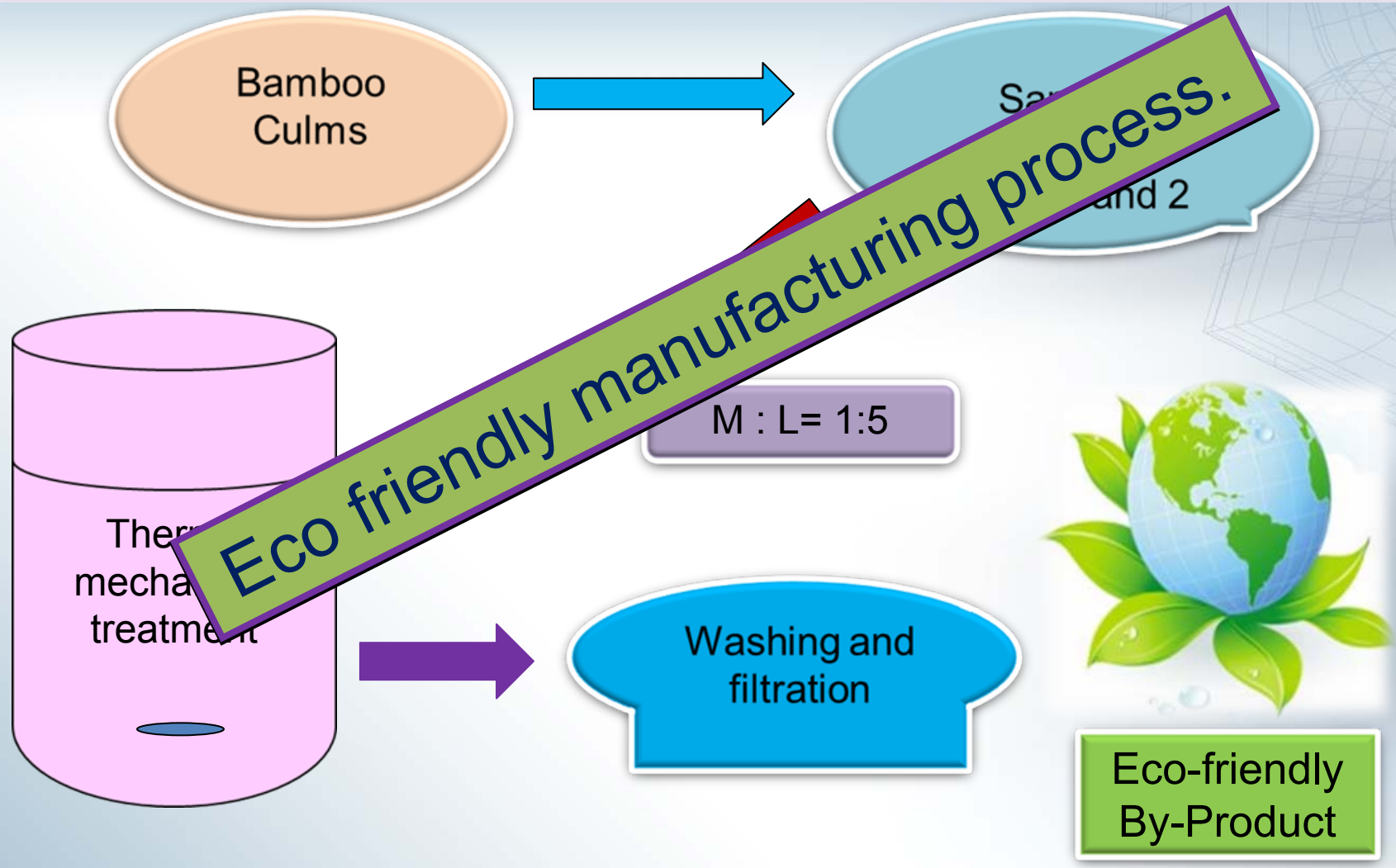






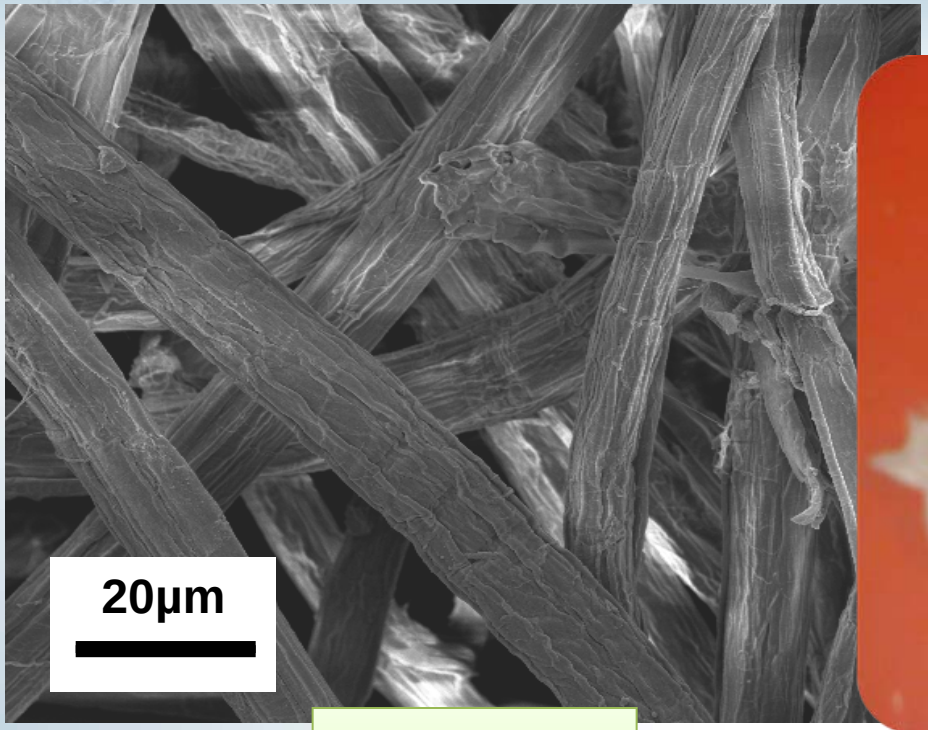
Bamboo fibres can be processed without any chemical aid.

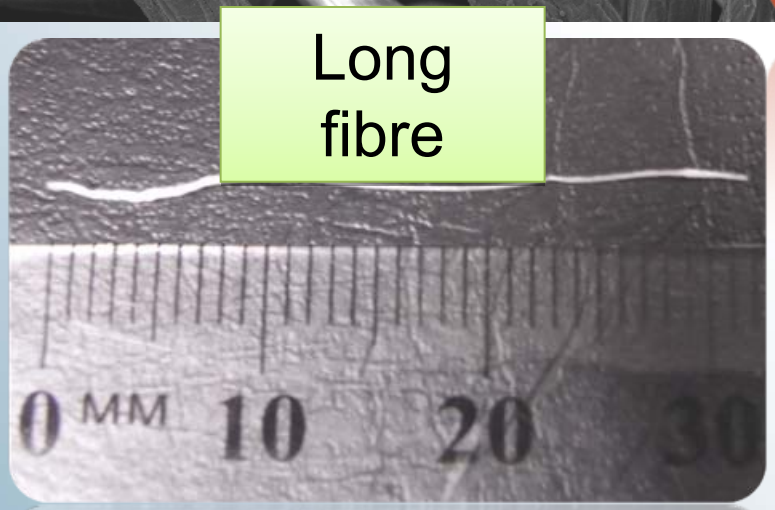
Processing of bamboo

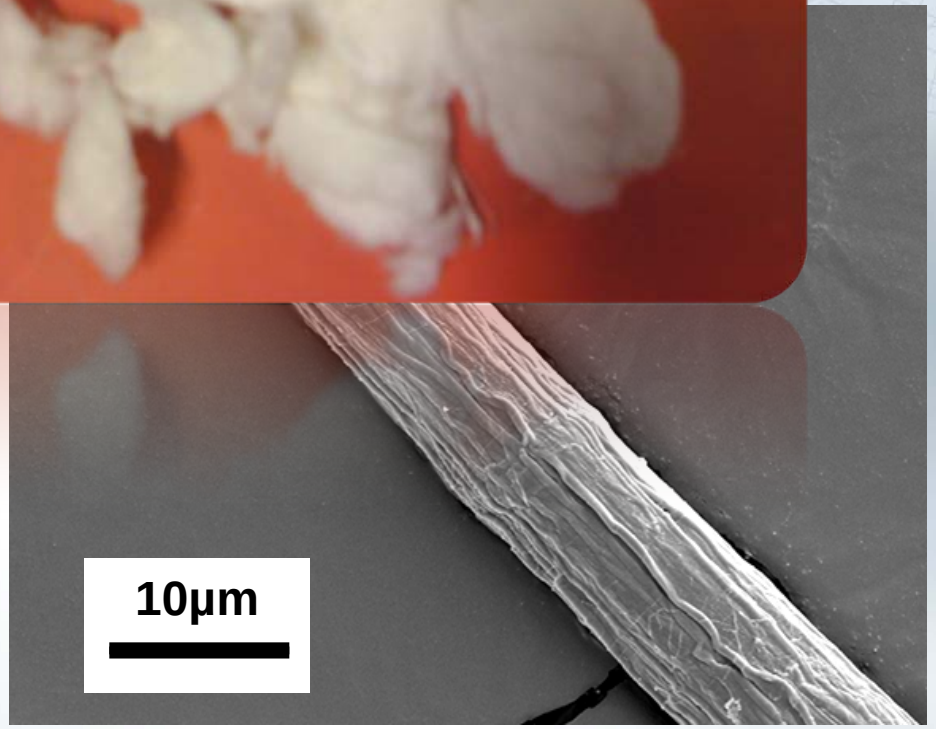


Afrin et al., 2011, Australian provisional patent: 2011902451

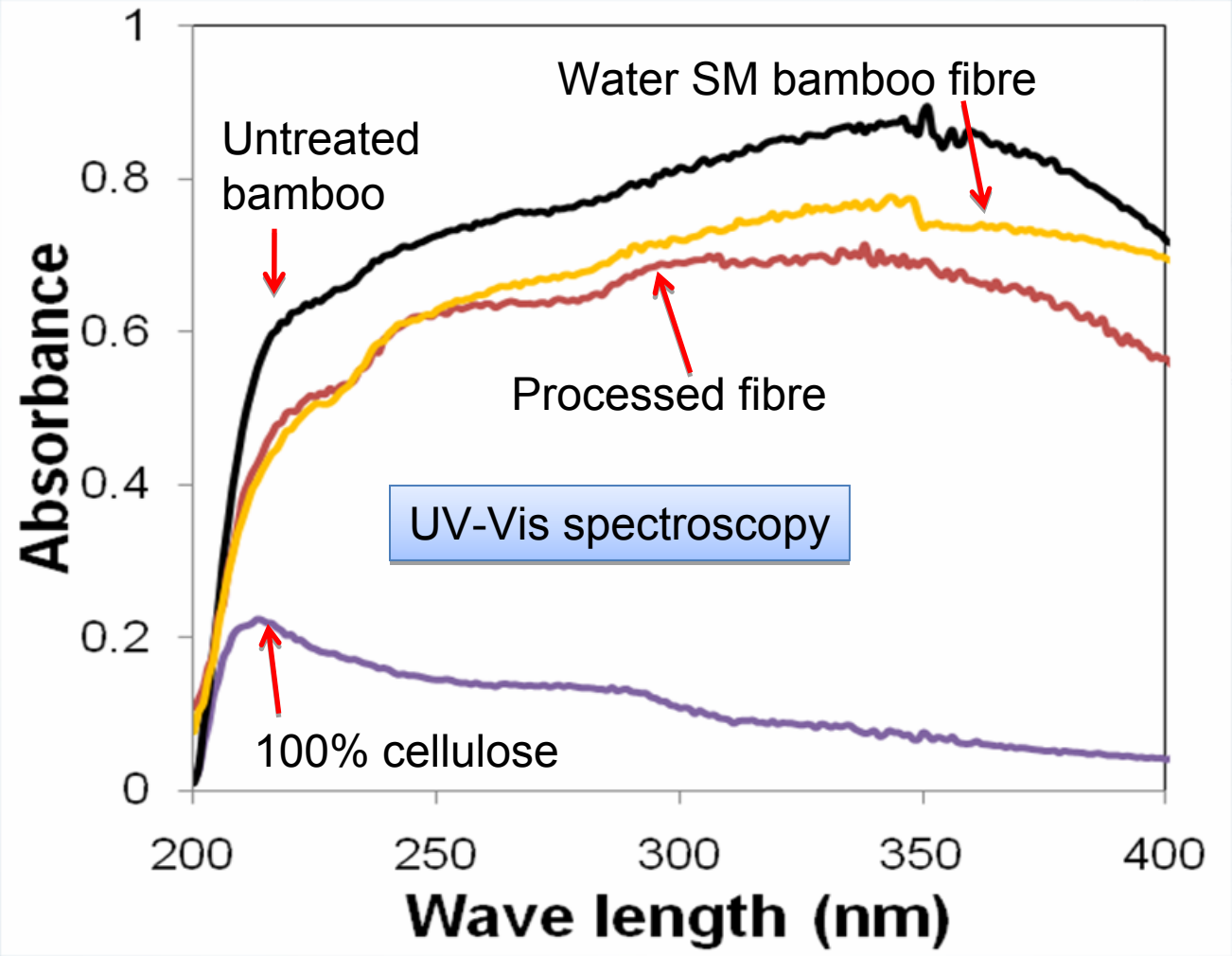
Morphology: processed fibre





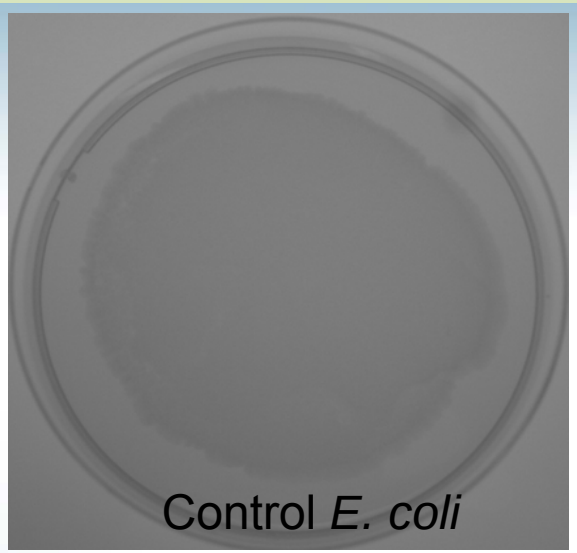


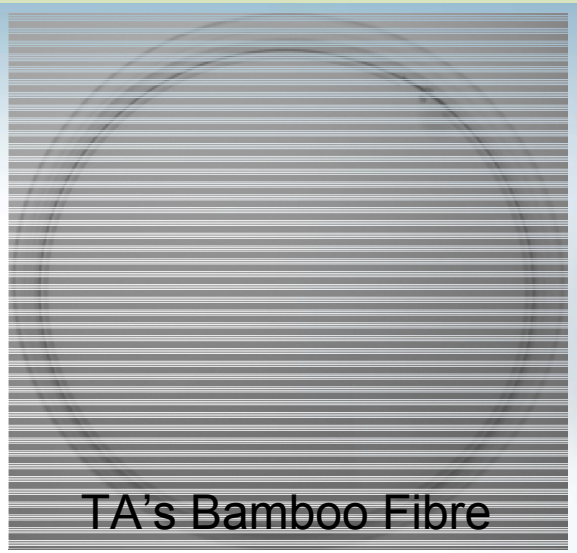
Comparison: UV absorbance

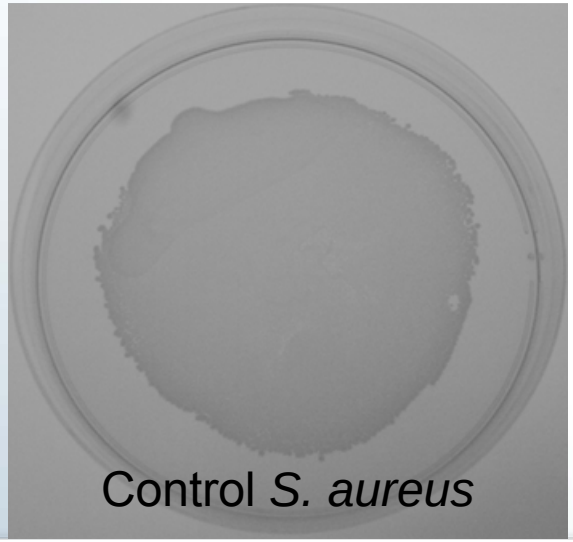


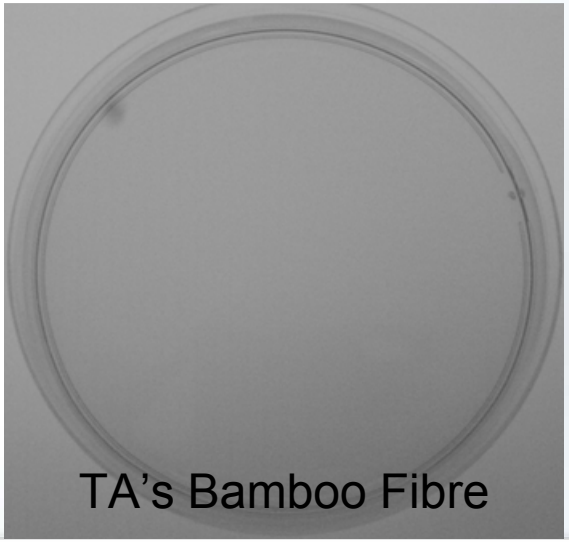
UV blocking ability is preserved after processing.

Antimicrobial property of processed fibre



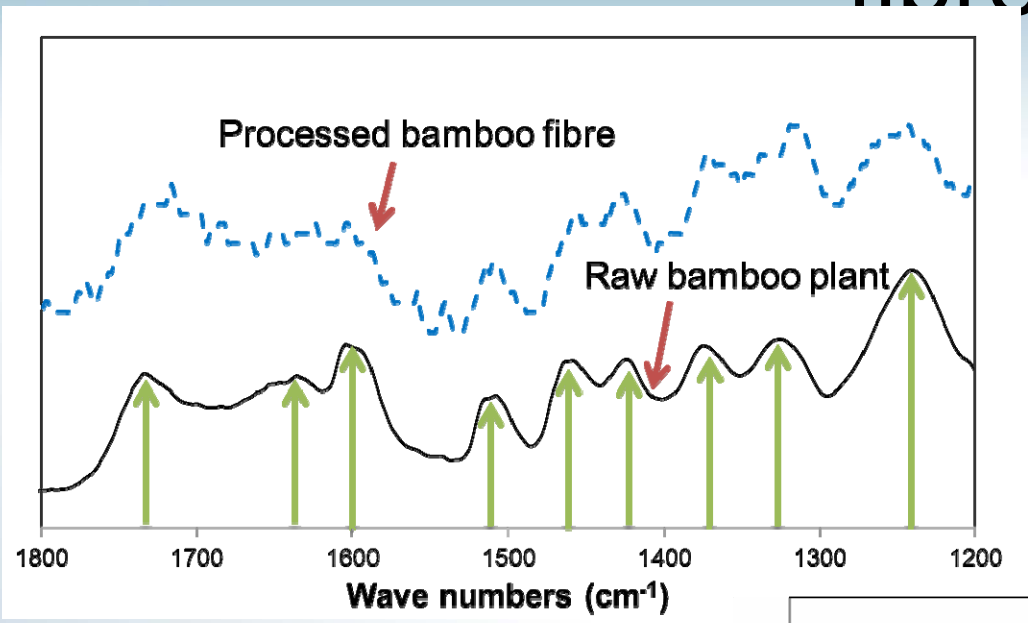


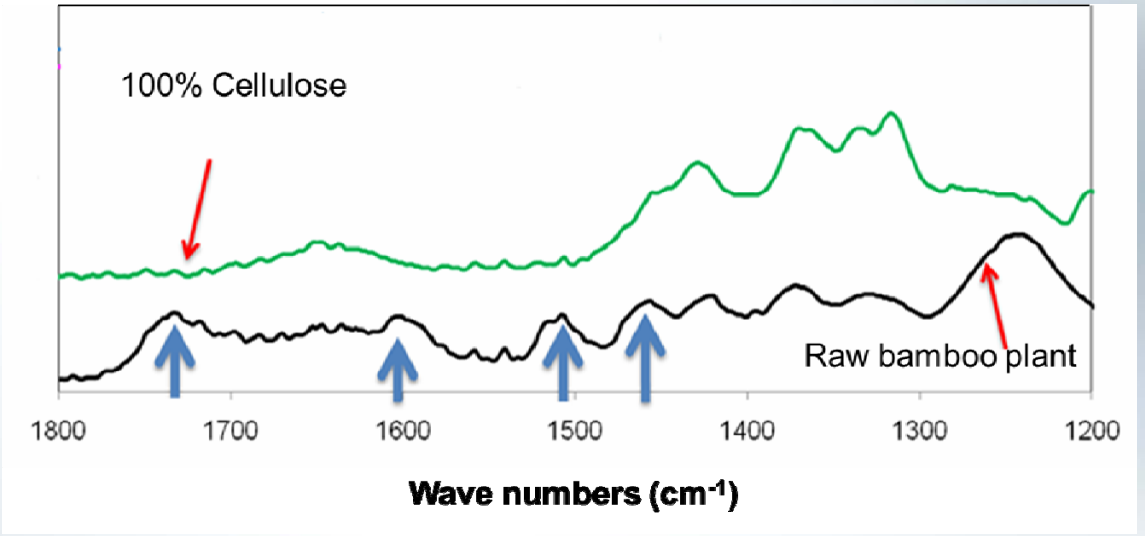




The processed fibres have shown outstanding antibacterial property against fatal and pathogenic bacteria

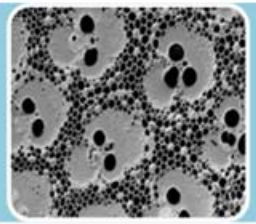
FT-IR spectroscopy of the processed fibre



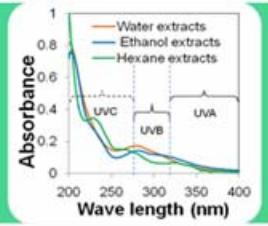


The functional bonds of lignin are retained into the processed fibre

Summary



Bamboo species used for this study is cellulose-I 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

DEAKINRESEARCH NOVEMBER 2010

Bamboo fashion

936 ABC Hobart

702 ABC Sydney

Acknowledgements

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

Australian Government

BAMBOO SOCIETY of AUSTRALIA

Email: taf@deakin.edu.au

INSTITUTE FOR
FRONTIER
MATERIALS
REAL WORLD SOLUTIONS

DEAKIN
UNIVERSITY AUSTRALIA

Thank You!