Barrier, Mechanical and Surface Properties of Nanocellulose-based Films with Polyhydroxyalkanoates Processed by the Electrospinning Coating Technique

Adriane Cherpinski Correa

Short-Term Scientific Mission (STSM)

cost

EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

COST is supported by the EU Framework Programme Horizon 2020

COST Provided me the opportunity to travel from Spain to Finland and to strengthen me in my academics as well in my social life.

iata

Instituto de Agroquímica
y Tecnología de Alimentos

Belongs to

CSIC

CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

Largest in Spain and third largest in Europe.

The Host Institution

Valtion teknillinen tutkimuskeskus

VTT Technical Research Centre of Finland Ltd is the leading research and technology company in the Nordic countries.

Purpose of the Visit

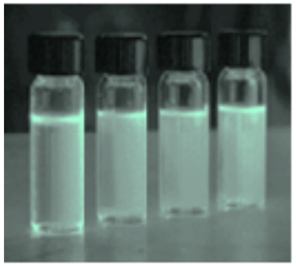
The structure of the packaging material is made of a nanocelullose film resembling paper board developed by VTT coated on both sides by an electrospun active PHA coating developed by CSIC.

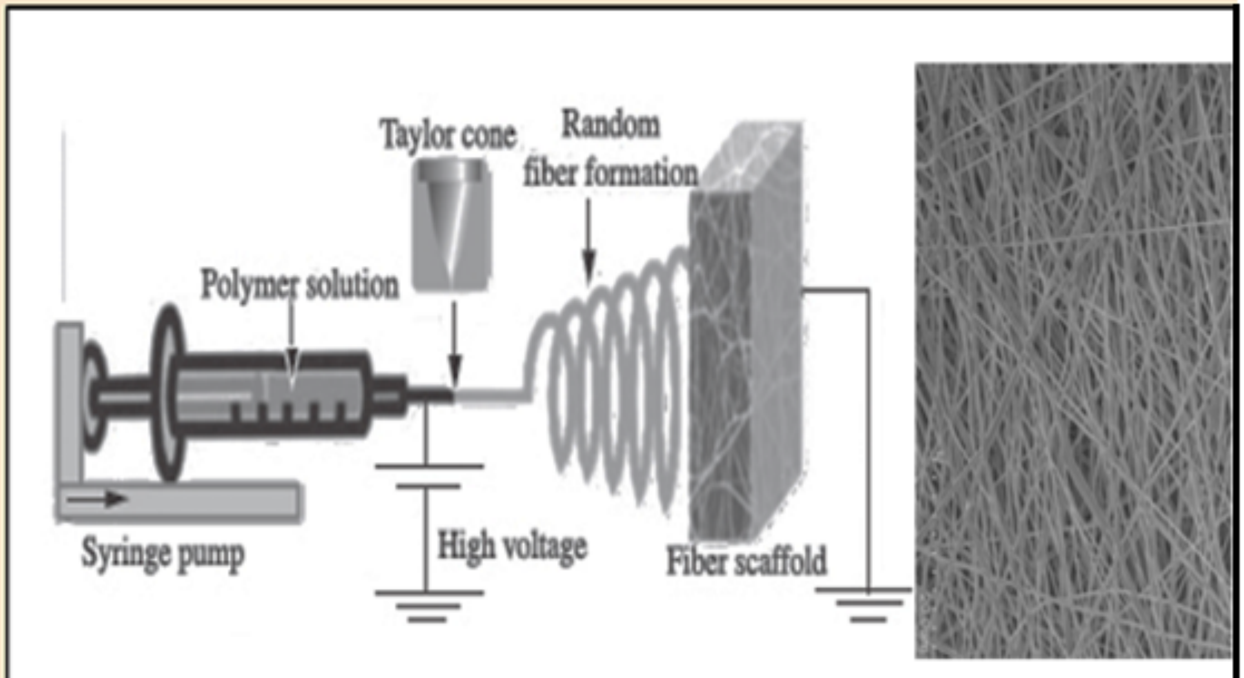
In our recent project, we are optimizing different coating systems using the Electrospinning technique;

The nanopaper was obtained at VTT and sent to the IATA-CSIC to carry out the electrospinning coating with PHBV;

At VTT I carried out most of the characterization of the nanopaper and of the multilayers.

Materials and method





Schematic diagram of a basic electrospinning process

LE500 Fluidnatek™ Electrospinning Pilot System

Characterization Techniques

Following material characterization techniques were used at VTT Finland during the visit.

- Biopackaging structure, multilayer of nanopaper
- Mechanical Properties (MP);
- Contact Angle Measurements (CAM);
- Atomic Force Microscopy (AFM);
- Water and Limonene Permeance (WVP);
- Oxygen Permeance (OP).

Some of the most relevant results follow

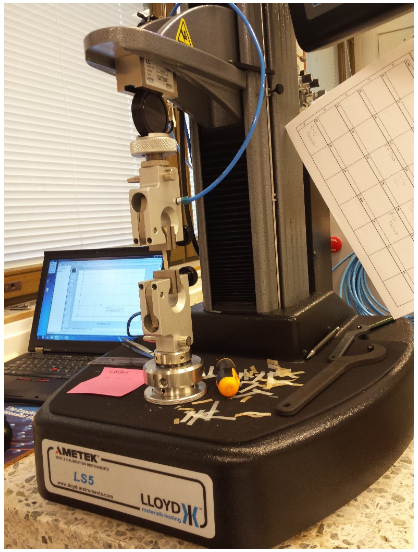
Nanopaper Structures Developed

Nanopaper

ePHBV

ePHBV/Nanopaper/ePHBV

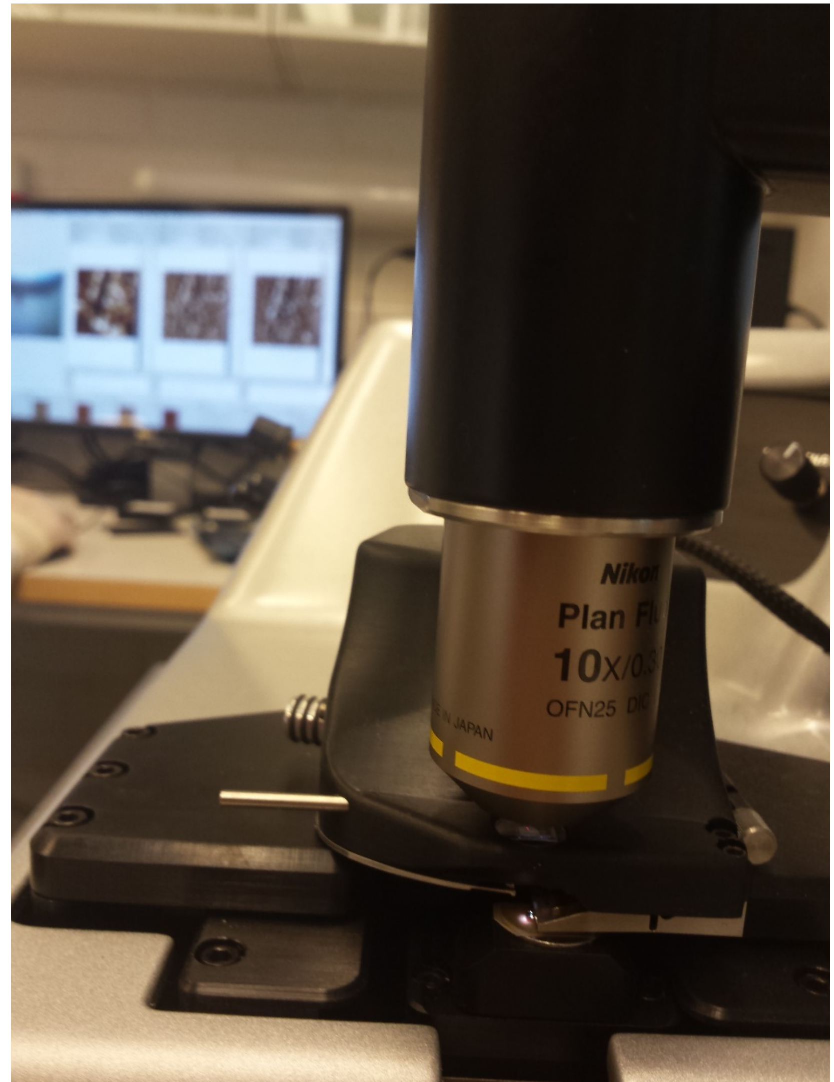
Mechanical Properties (MP)



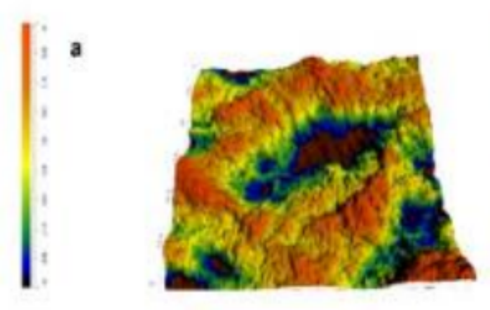
Sample	E (MPa)	σ_y (MPa)	σ_b (MPa)	ε_b (%)
CNF	4504.2 ± 105[a]	48.4 ± 4.5[a]	137.7 ±9.3[a]	18.1 ± 2.2[a]
PHBV	2014.9 ± 155[d]	28.0 ± 3.2[c]	33.0 ± 4.8[e]	2.8 ± 0.1[d]
PHBV/CNF/PHBV	2056.7 ± 78[c]	21.0 ± 1.8[d]	37.7 ± 0.6[d]	5.9 ± 0.6[c]

- **The modulus, yield stress and tensile strength** of the multilayer is **lower than that of the nanopaper** due to the double coating.
- **The elongation at break is also lower** than that of the nanopaper **but it is higher** than **that of the pure PHBV**.

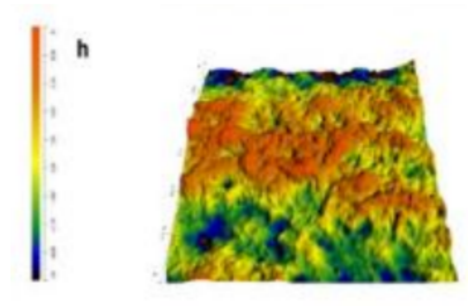
Atomic Force Microscopy (AFM)



Atomic Force Microscopy (AFM)



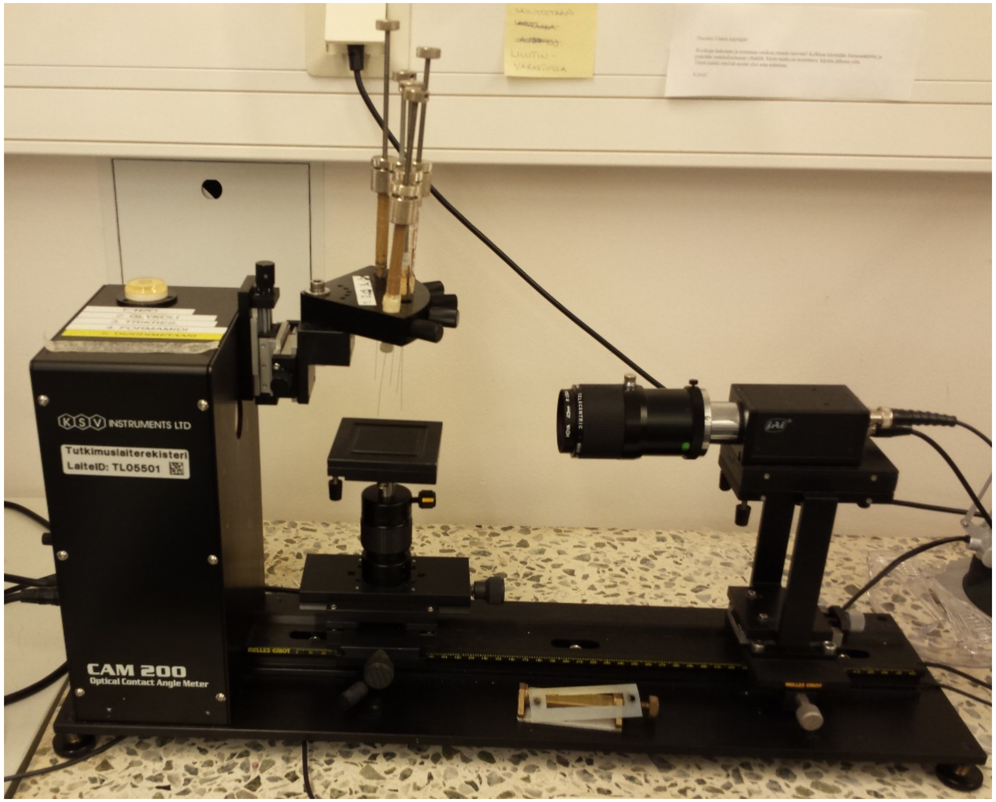
Nanopaper

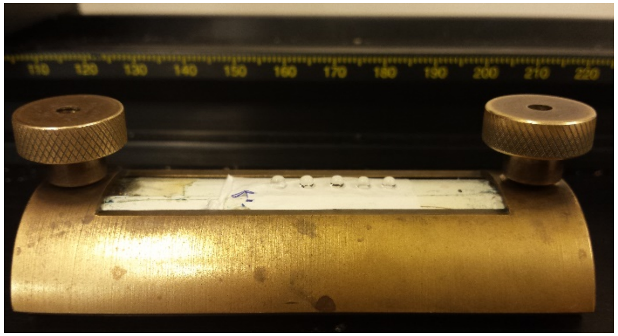


Multilayer PHBV/Nanopaper/PHBV

The **surface roughness** of the nanopaper **decreases after coating,** as a result the mutilayer has a smoother and glossier surface due to the enhanced surface homogeneity provided by the electrospinning process

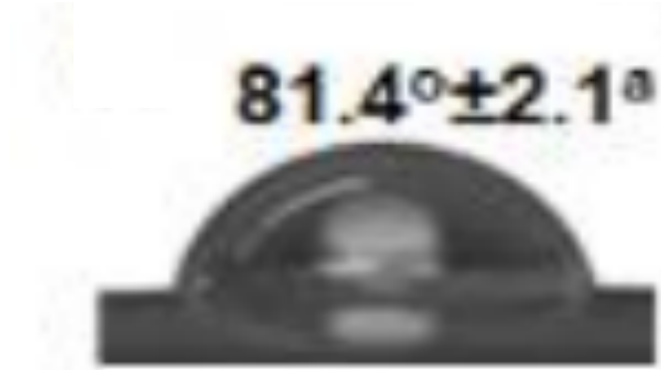
Contact Angle Measurements (CAM)





Contact Angle Measurements (CAM)

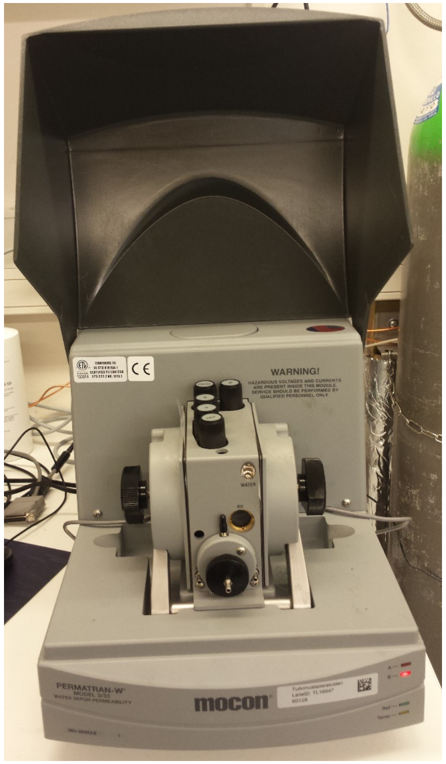
Nanopaper

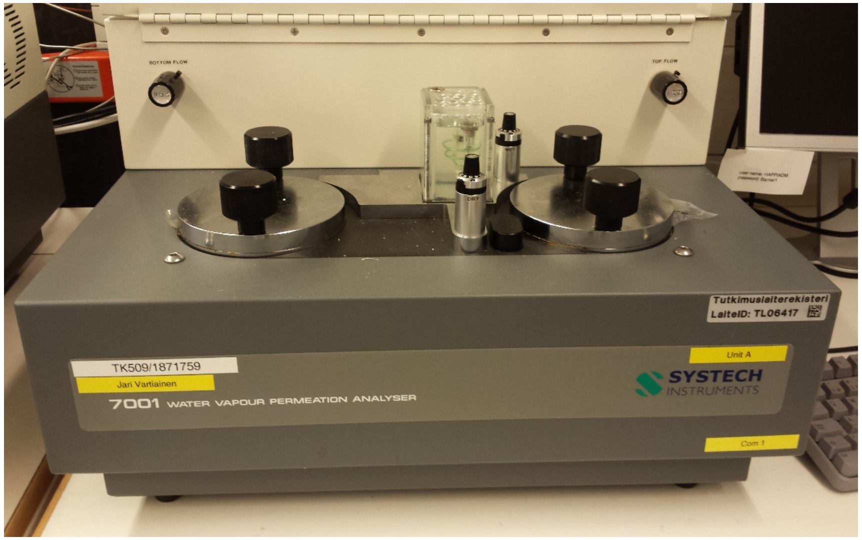


Multilayer PHBV/Nanopaper/PHBV

The **contact angle increases** significantly **after coating** suggesting that PHBV results in strong hydrophobization of the nanopaper

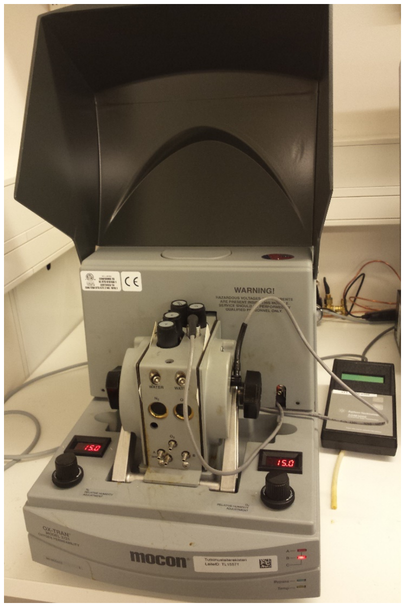
Water Vapor and Limonene Permeance of the multilayer





- **Water vapour permeance** was seen to **drop** in the multilayer as compared to the pure nanopaper by **more than two orders of magnitude** due to coating with PHBV.
- **Limonene permeance** on the other hand was seen to **increase** in the multilayer **by one order of magnitude** because limonene plasticizes PHBV.

O_2 Permeance



Oxygen permeance was measured at 60%RH and **was seen to drop in the multilayer by ca. 40%** as compared to the pure nanopaper due a reduced moisture induced plasticization.

Conclusions

The electrospinning coating technique proves to be a very efficient method to strongly reduce the water permeability of nanopapers and to a lesser extent also to oxygen when PHAs were used as the coating materials

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