# Barrier Coating of Paperboard

Samir Kopacic[a], Andrea Walzl[b], Armin Zankel[c], Rudolf Kniely[a], Erich Leitner[b] and Wolfgang Bauer[a]

[a]Institute of Paper, Pulp and Fiber Technology, Graz University of Technology
[b]Institute for Analytical Chemistry and Food Chemistry, Graz University of Technology
[c]Institute for Electron Microscopy and Nanoanalysis, NAWI Graz, Graz University of Technology and Centre for Electron Microscopy

# Overview

- Challenge and Opportunity
- Barrier Materials
- Coating Trials
- Characterisation and Barrier Performance
- Summary and Outlook

# Challenge and Opportunity

# Aim

- Testing and evaluation of potential barrier biomaterials for paper based packaging
- Replacement of synthetic barriers
- Utilization of existing coating technology used in paper and packaging industry (film press, curtain coater, size press)

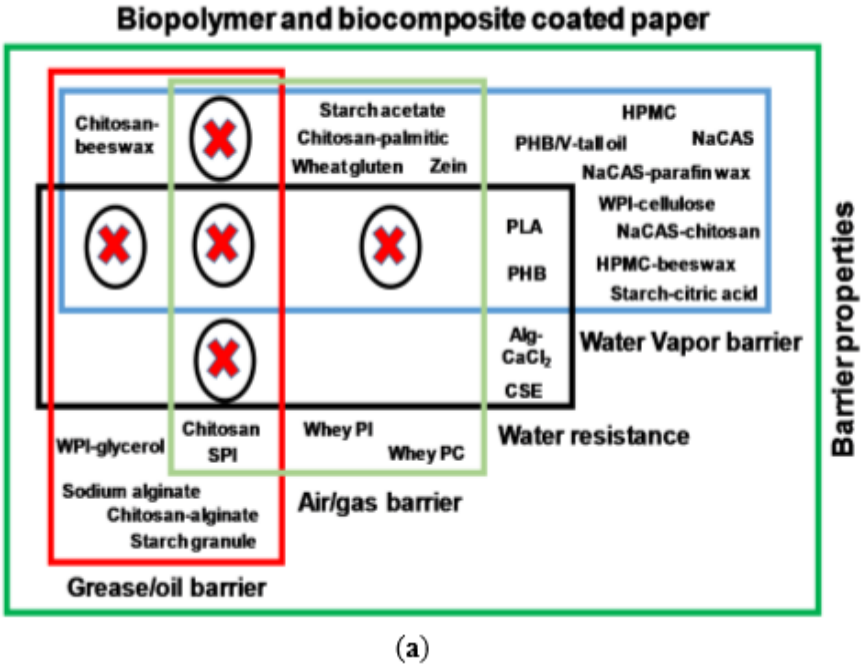
# Barriers and Potential Barrier Materials

## Literature Studies

**Type of barrier:**

- **Oil/grease**
- **Gas (Oxygen, Air)**
- **Water**
- **Water vapour**
- ***Aroma***
- ***Mineral Oil***

***(MOSH and MOAH)***

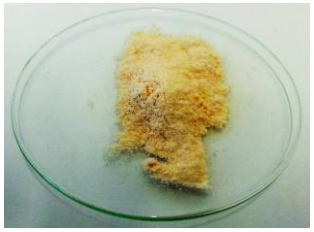


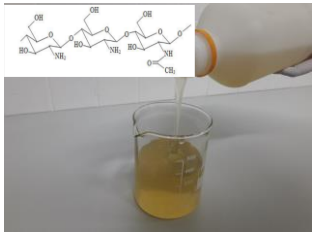

*Vibhore Kumar Rastogi et. al* (2015). *Coatings*,5, 887-930.

# Our Approach

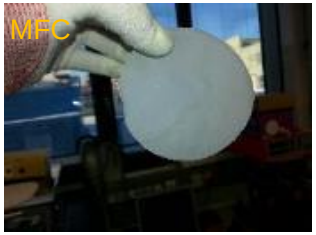
## 1. Part

### Solubilisation and Flow behaviour

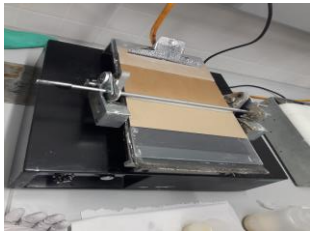




### Free-Standing Foil and Film

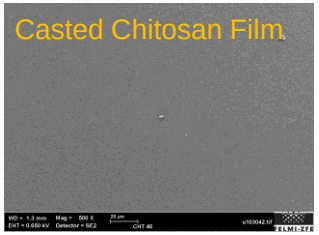



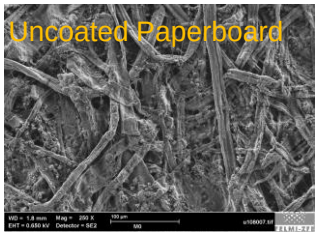

### Coating and Coatability



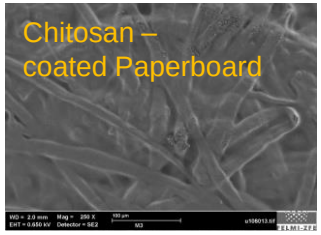
## 2. Part

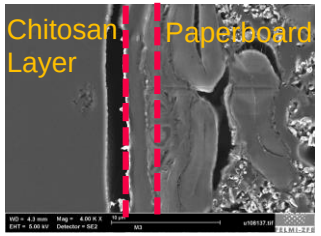
### Surface Properties



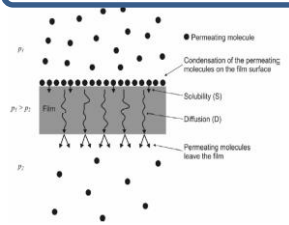



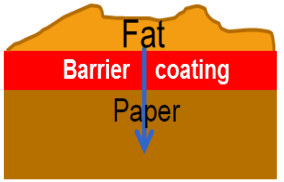

### Paper-Barrier Interaction



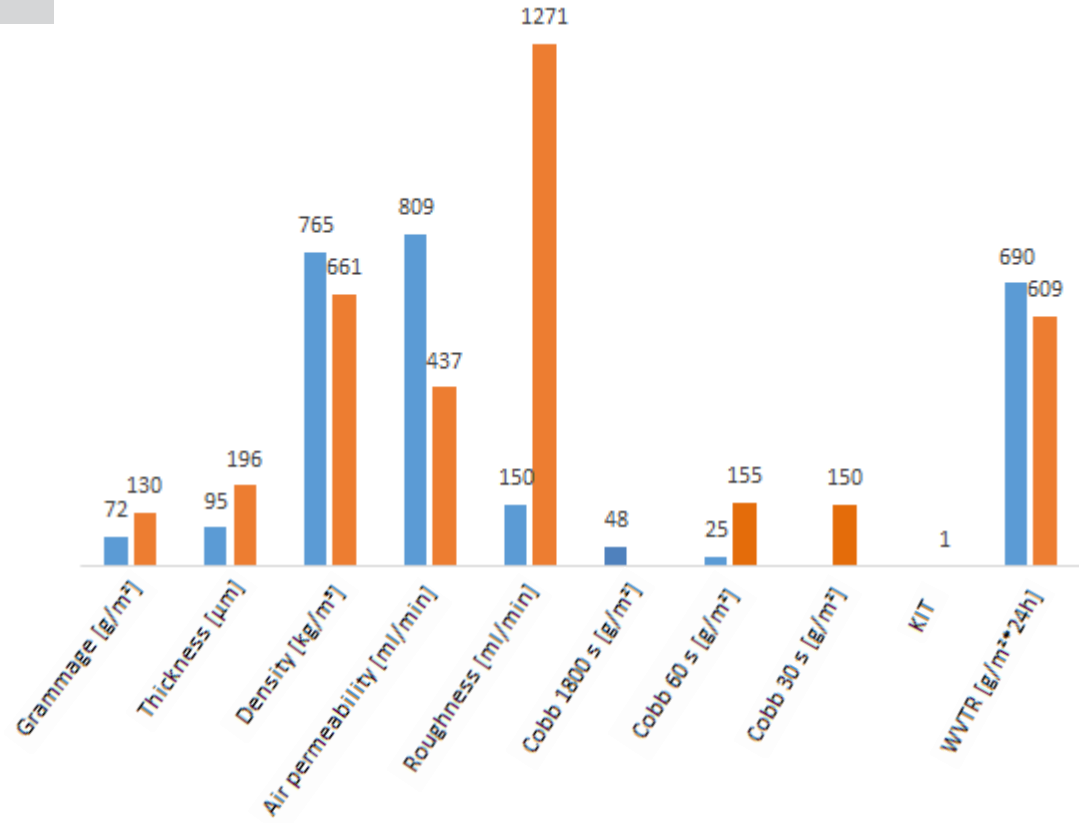

### Permeability and Barrier Properties

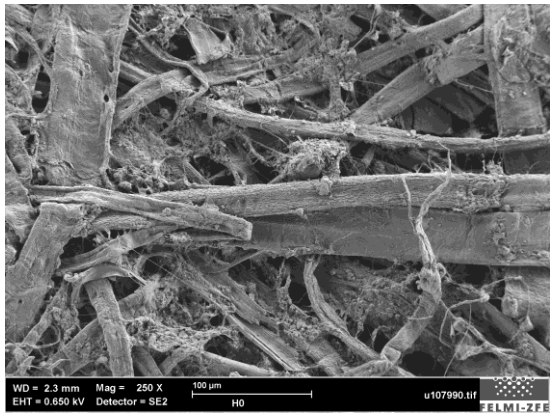


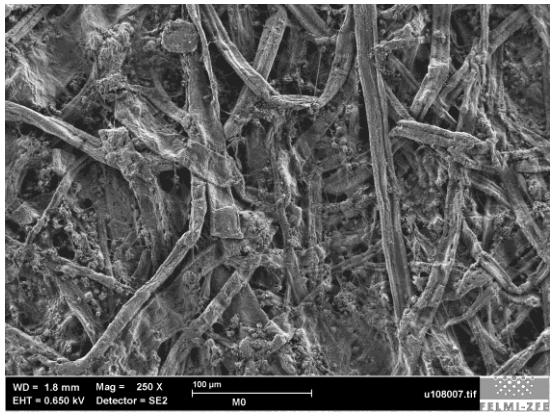
# Materials – Raw (Uncoated) Paperboard

SF – 100 % recycled fiber - unsized
PF – 100 % virgin fiber - (starch) sized



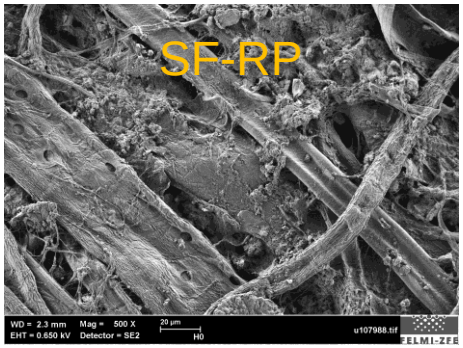

RP - SF

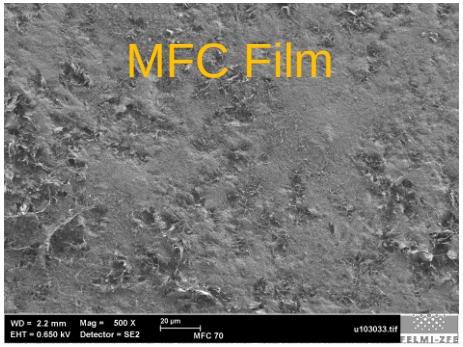


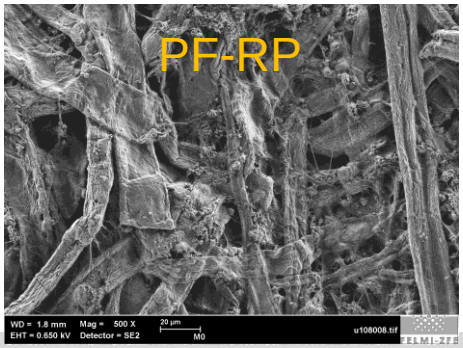

RP - PF

# Surface Characterization

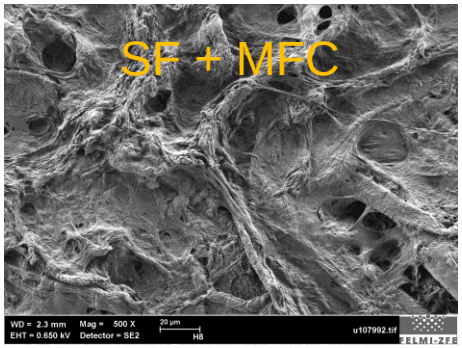
## Scanning Electron Microscope (SEM)

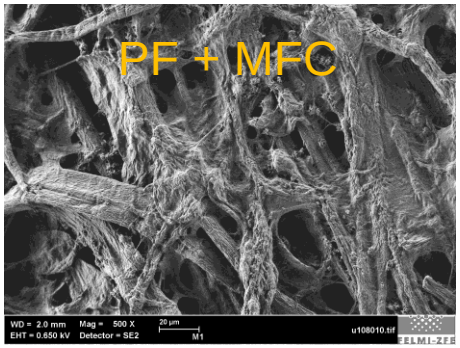



Paper Coating vs. Film Casting

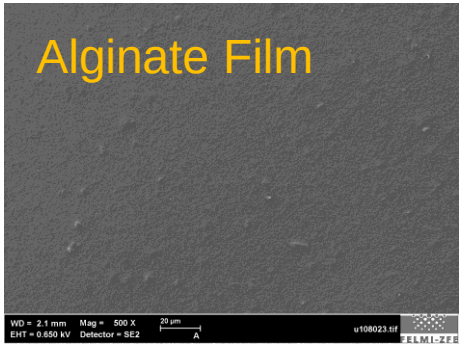


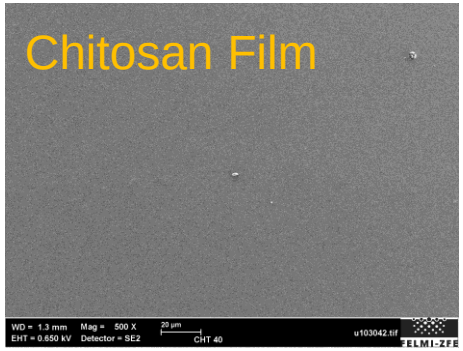



# Surface Characterization

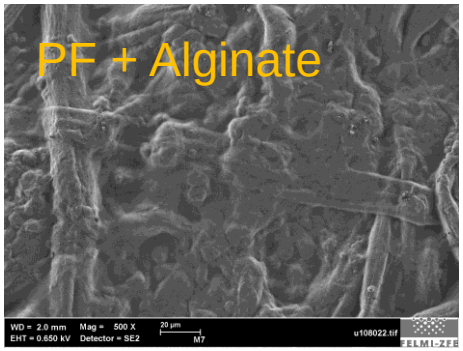
## Scanning Electron Microscope (SEM)

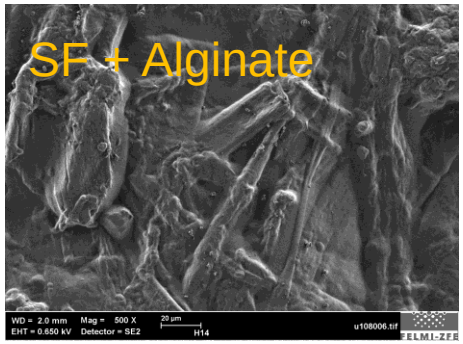
**Free-standing Film**

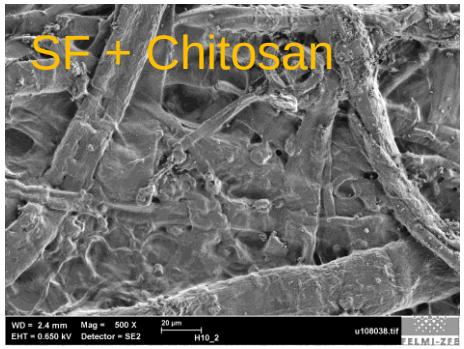


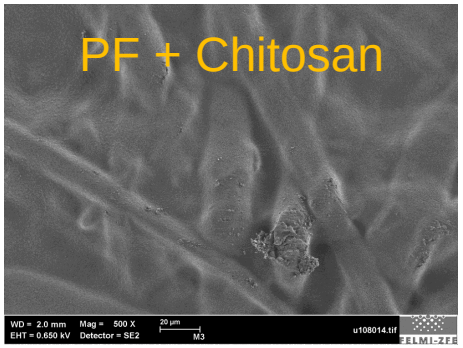




**Coated Paper – Primary and Secondary Fibre**



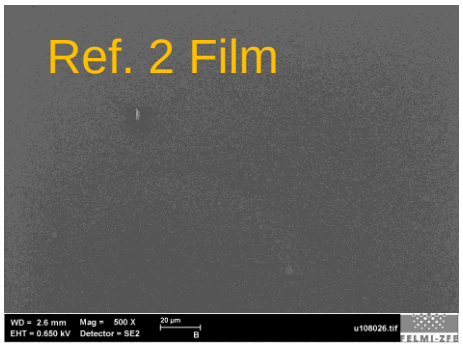



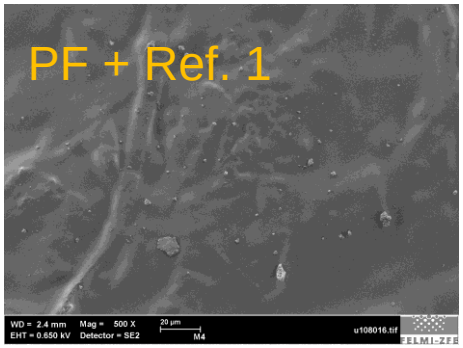
# Surface Characterization

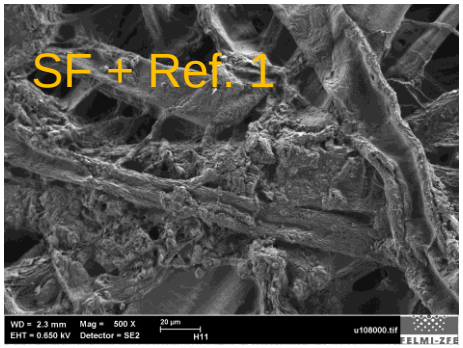
## Scanning Electron Microscope (SEM)

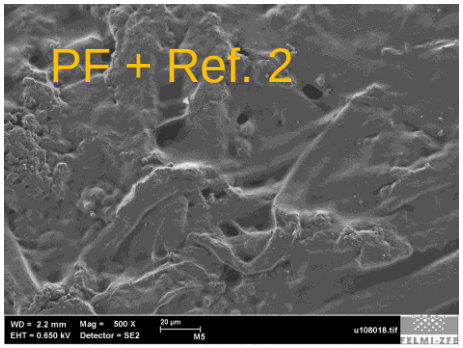
**Free-standing Film**

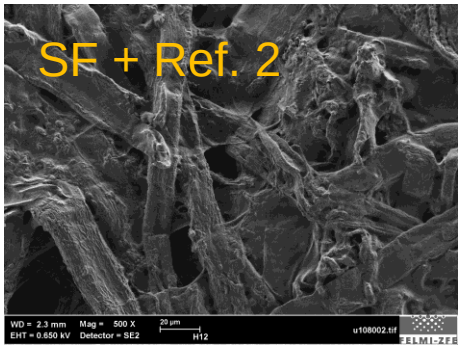




**Coated Paper – Primary and Secondary Fibre**



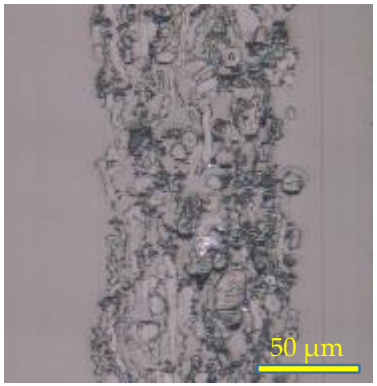



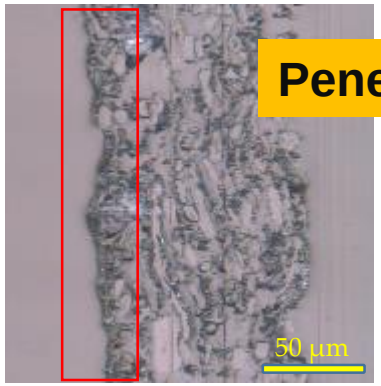



# Thickness and Penetration

## LIMI + Microtome (IPZ)

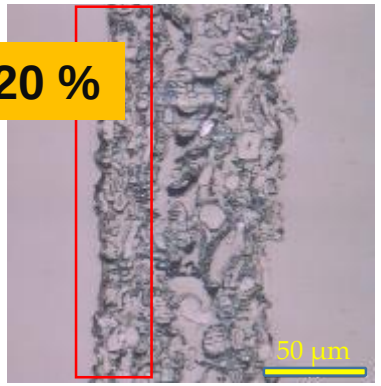



PF Uncoated



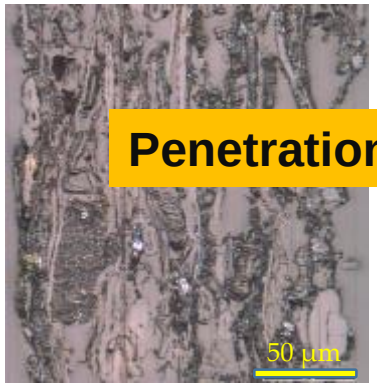

PF + Chitosan

**Penetration ~ 20 %**



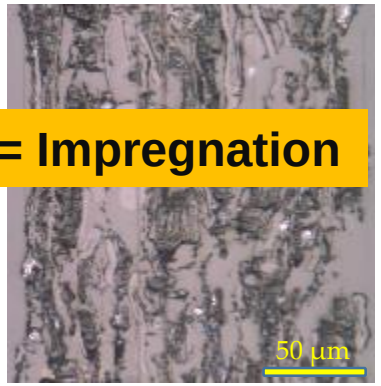

PF + Alginate


SF Uncoated




SF + Chitosan

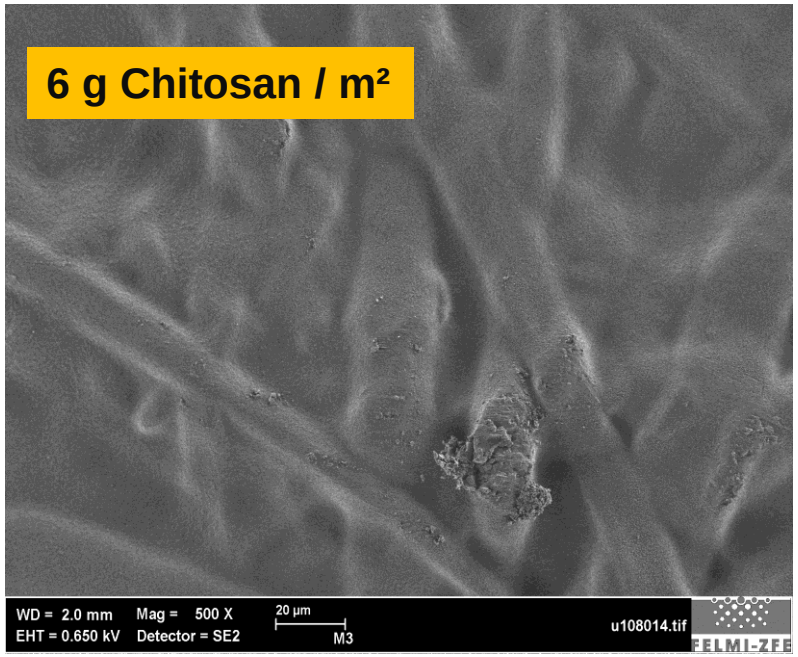
**Penetration = 100 % = Impregnation**



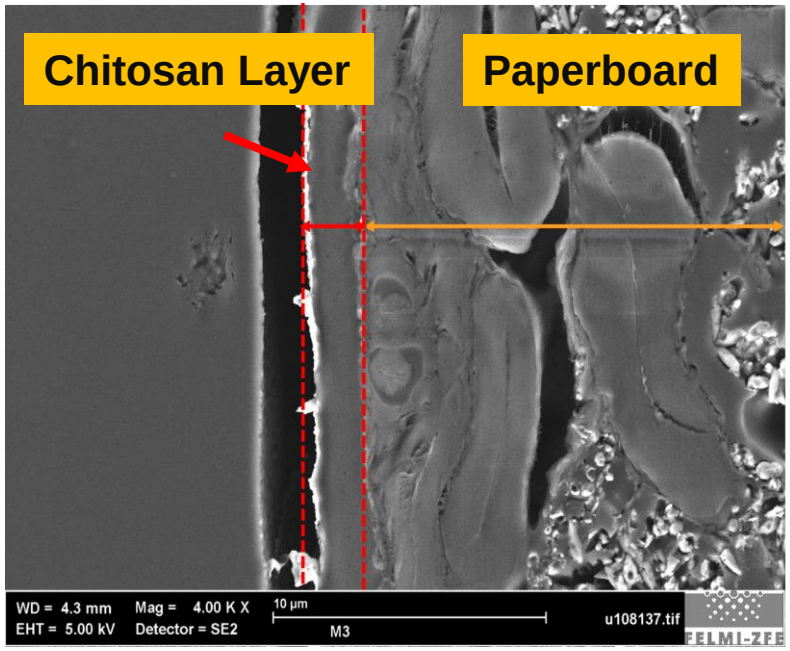

SF + Alginate

# Barrier Thickness (SEM+M)

## PF Paper + Chitosan




**PF Paper + Chitosan**



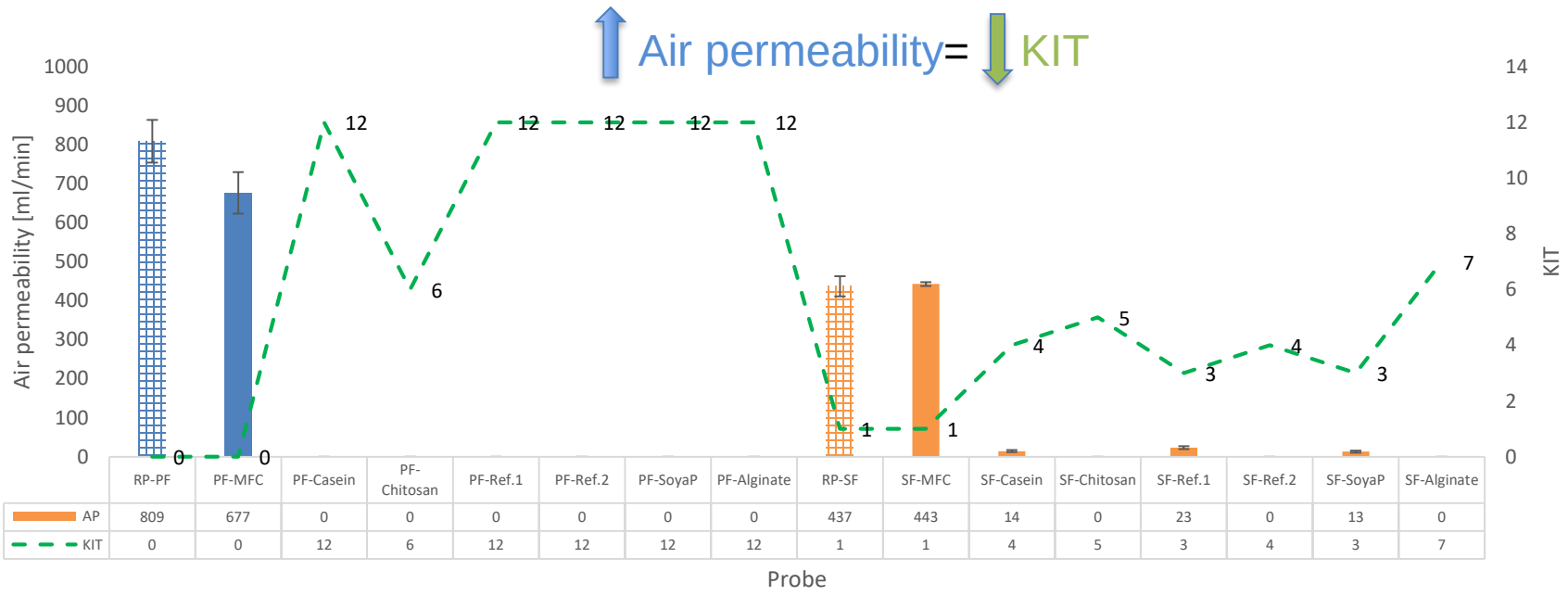

**SEM + Microtome**

- **Barrier Thickness = <u>3,2 µm</u>**

*scale

# Grease Resistance vs. Air Permeability

## Primary vs. Secondary Fiber



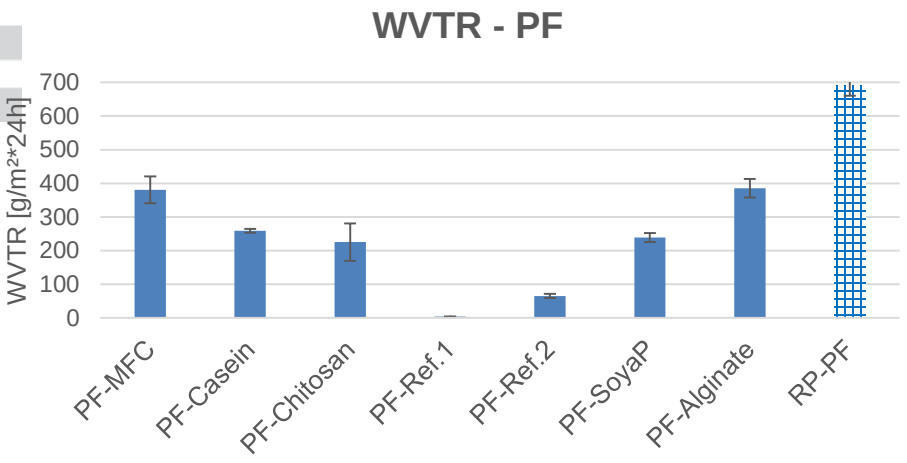

| | RP-PF | PF-MFC | PF-Casein | PF-Chitosan | PF-Ref.1 | PF-Ref.2 | PF-SoyaP | PF-Alginate | RP-SF | SF-MFC | SF-Casein | SF-Chitosan | SF-Ref.1 | SF-Ref.2 | SF-SoyaP | SF-Alginate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AP | 809 | 677 | 0 | 0 | 0 | 0 | 0 | 0 | 437 | 443 | 14 | 0 | 23 | 0 | 13 | 0 |
| KIT | 0 | 0 | 12 | 6 | 12 | 12 | 12 | 12 | 1 | 1 | 4 | 5 | 3 | 4 | 3 | 7 |

- **SF-coated**
  KIT > 5 with Cht, Alg
- **PF-coated**
  KIT = 12 with Cas, Ref.1, Ref.2, SP, Alg

| KIT No. | Grease resistance |
|---|---|
| 1,2.. | Extremely low |
| 3,4,5,…. | Medium to high |
| 11,12 | Very high resistance |

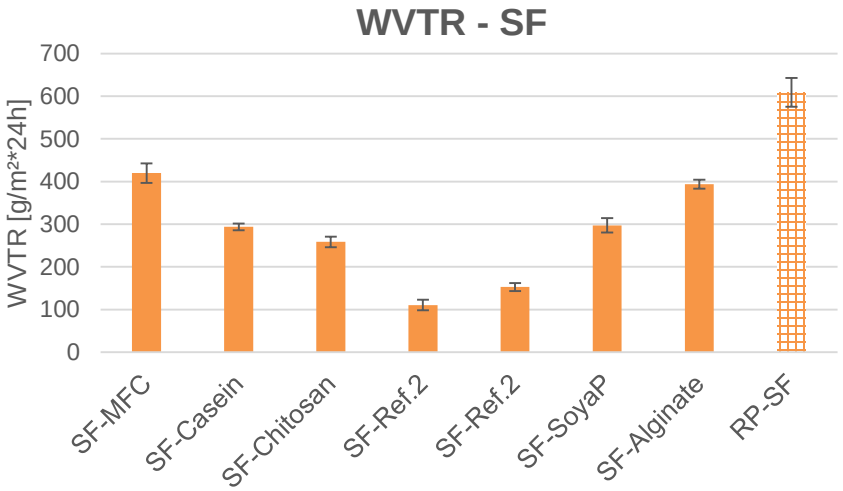
# Water Vapor Transmission

## Primary vs. Secondary Fiber



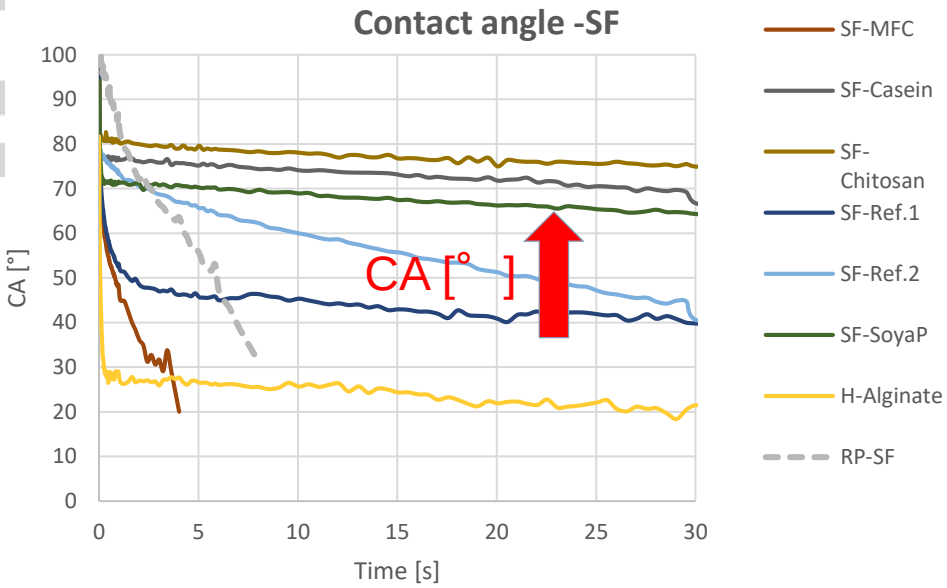

$$WVT = \frac{\left(\frac{G}{t}\right)}{A}$$

**WVTR** coated < **WVTR** uncoated

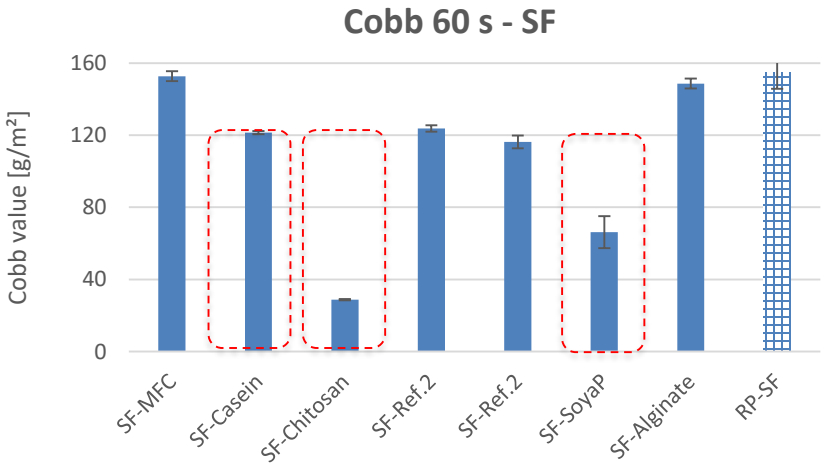


# Water Absorptiveness and Wettability

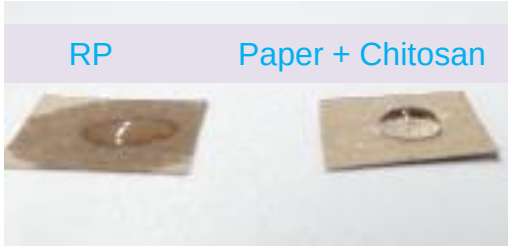
## Secondary Fiber




- Measurable Cobb 60s: Chitosan, SP and Casein

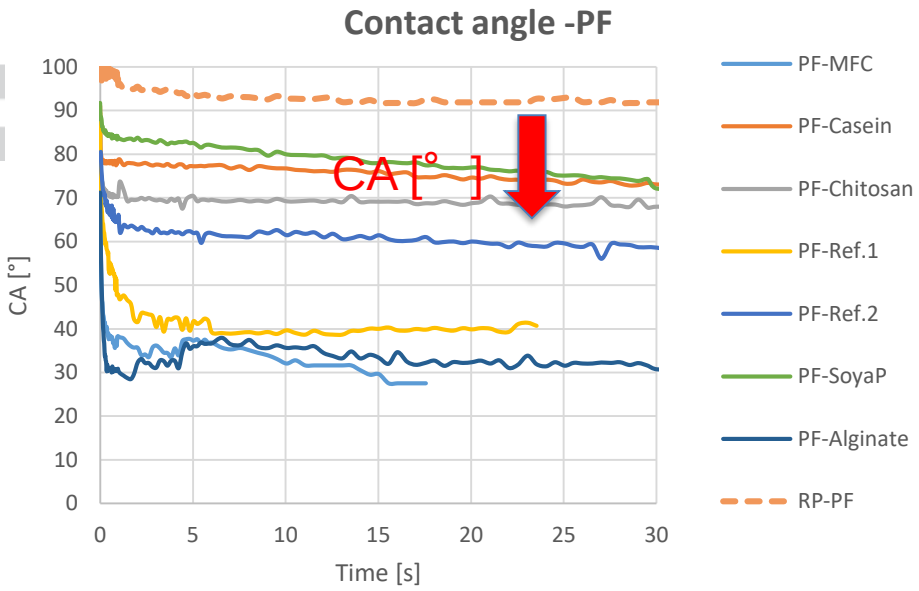



- Hydrophobization effect with SP, Chitosan and Casein



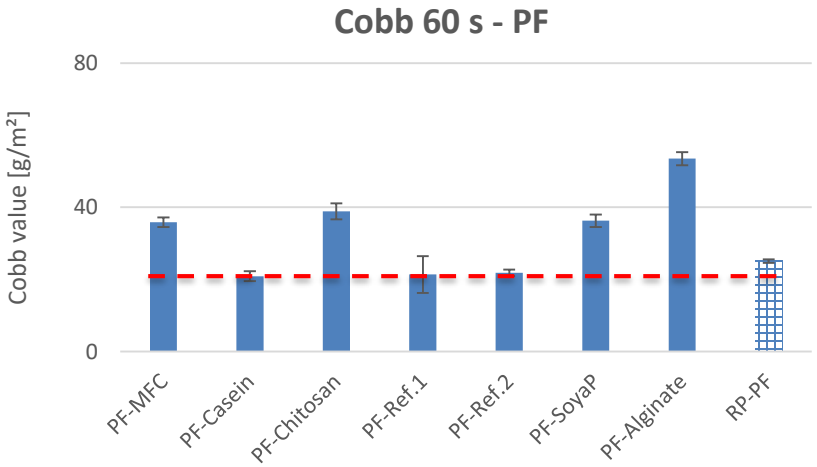
# Water Absorptiveness and Wettability

## Primary Fiber

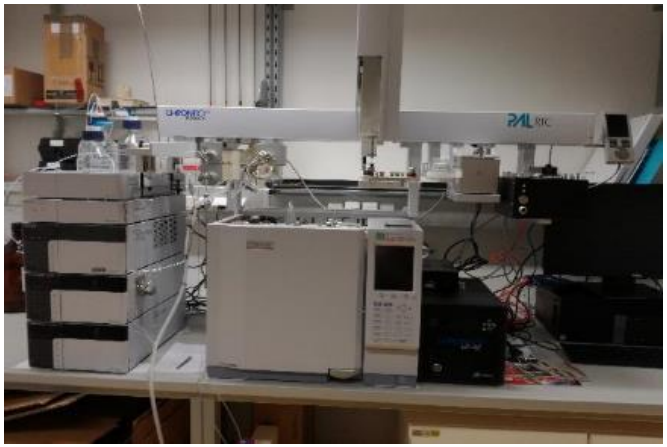


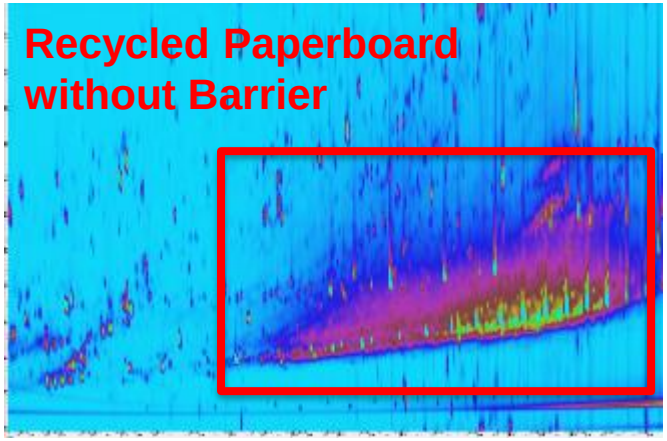

- Hydrophilization effect
- Cobb and CA correlate!

- Measurable Cobb 60 s: Ref.1, Ref.2 und Casein



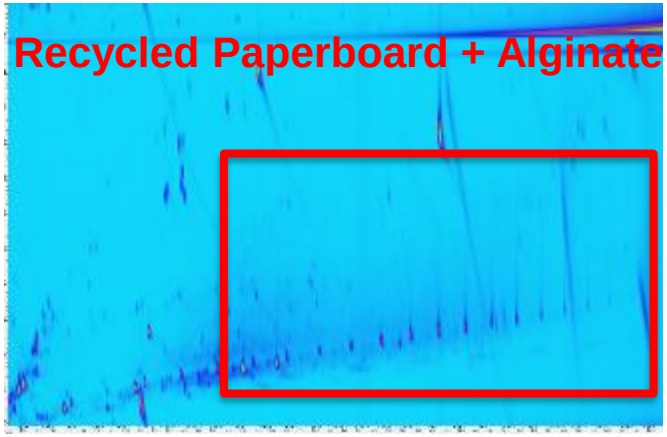
# Recycled Paperboard - Source of Mineral Oil






**MOSH** (mineral oil saturated hydrocarbons)

**MOAH** (mineral oil aromatic hydrocarbons)



# Recycled Paperboard - Source of Mineral Oil

| | Migration [%] | MOH [%] | MOSH [%] | MOAH [%] | Remainings [%] |
|---|---|---|---|---|---|
| **Recycled uncoated paper** | 100 | 63.8 ± 0.1 | 57.8 ± 0.1 | 6.02 ± 0.16 | 36.2% |
| **Alginate coated paper** | 16.3 ± 1.0 | 7.9 ± 0.25 | 5.49 ± 0.18 | 2.41 ± 0.42 | 8.4% |
| **Chitosan coated paper** | 29.5 ± 1.6 | 9.16 ± 0.3 | 8.43 ± 0.2 | 0.73 ±0.34 | 20.3% |

**remainings consist of substances with a retention time outside the range of $C_{16}$-$C_{35}$ and substances subtracted from MOH e.g. DIPN*

# Summary and Outlook

## Biomaterials for Barrier Coating

- Medium to high grease resistance
- Improved water vapor permeability and MO Migration/Permeation
- Hydrophilization and hydrophobization effects observed
- Multifunctional barrier properties (Chitosan, Alginate…)
- Film formation is not a prerequisite for good barrier properties

*Potential Barriers* ⇨ *Grease, Gas, Mineral oils…*

## Next steps

- Better understanding for paper-barrier interaction
- Application of film press
- Focus on 3-4 barrier materials and development of multi-component and multi-functional barrier formulations for packaging paper

# Acknowledgements

The author acknowledge the Austrian Research Promotion Agency (FFG) and ÖZEPA

The author further acknowledge the industrial and scientific partners

- **Heinzel Pulp Pöls**
- **Hamburger Pitten GmbH**
- **Mondi Group**
- **Smurfit Kappa**
- **Delfort Group**
- **ACFC (Erich Leitner and Andrea Walzl)**
- **IPZ (Wolfgang Bauer)**
- **FELMI (Armin Zankel)**

# Thank you very much for your attention!