Presentation at COST meeting, Bled 23.11.2016

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Short Term Scientific Misson

„OBTAINING OF PAPER SAMPLES, CONTAINING OF BIO-BASED COMPONENTS AND INVESTIGATION ON ITS INFLUENCE OVER THE PROPERTIES OF PAPER"

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cost
EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY

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Horizon 2020

STSM Duration (27.9.2016-04.10.2016)

Home Institution

University of Ljubljana

University of Ljubljana, Faculty of Natural Sciences and Engineering, Department of Textiles, Graphic Arts and Design

Ljubljana, Slovenia

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STSM Duration (27.9.2016-04.10.2016)

Host institution

University
of Chemical Technology
and Metallurgy
of Sofia

University of Chemical Technology and Metallurgy,
Department of Pulp, Paper and Printing Art

Sofia, Bulgaria

Dr. Dimitrina Todorova

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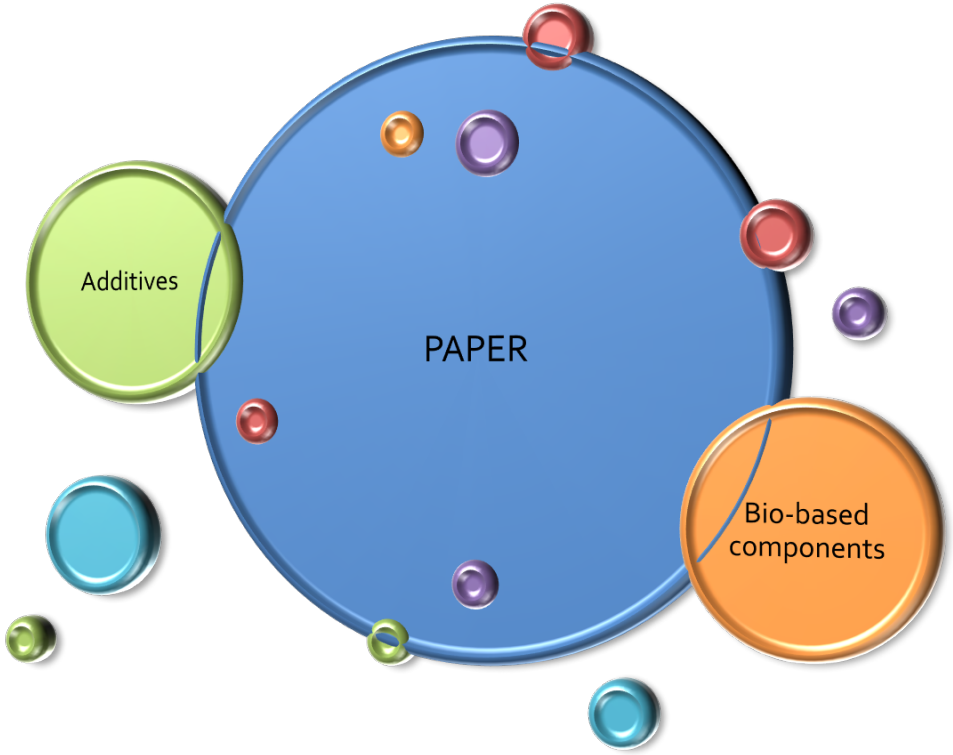
The main objective

To prepare paper samples containing bio-based components which will be included as fillers and not as coatings and to investigate the changes in paper properties.



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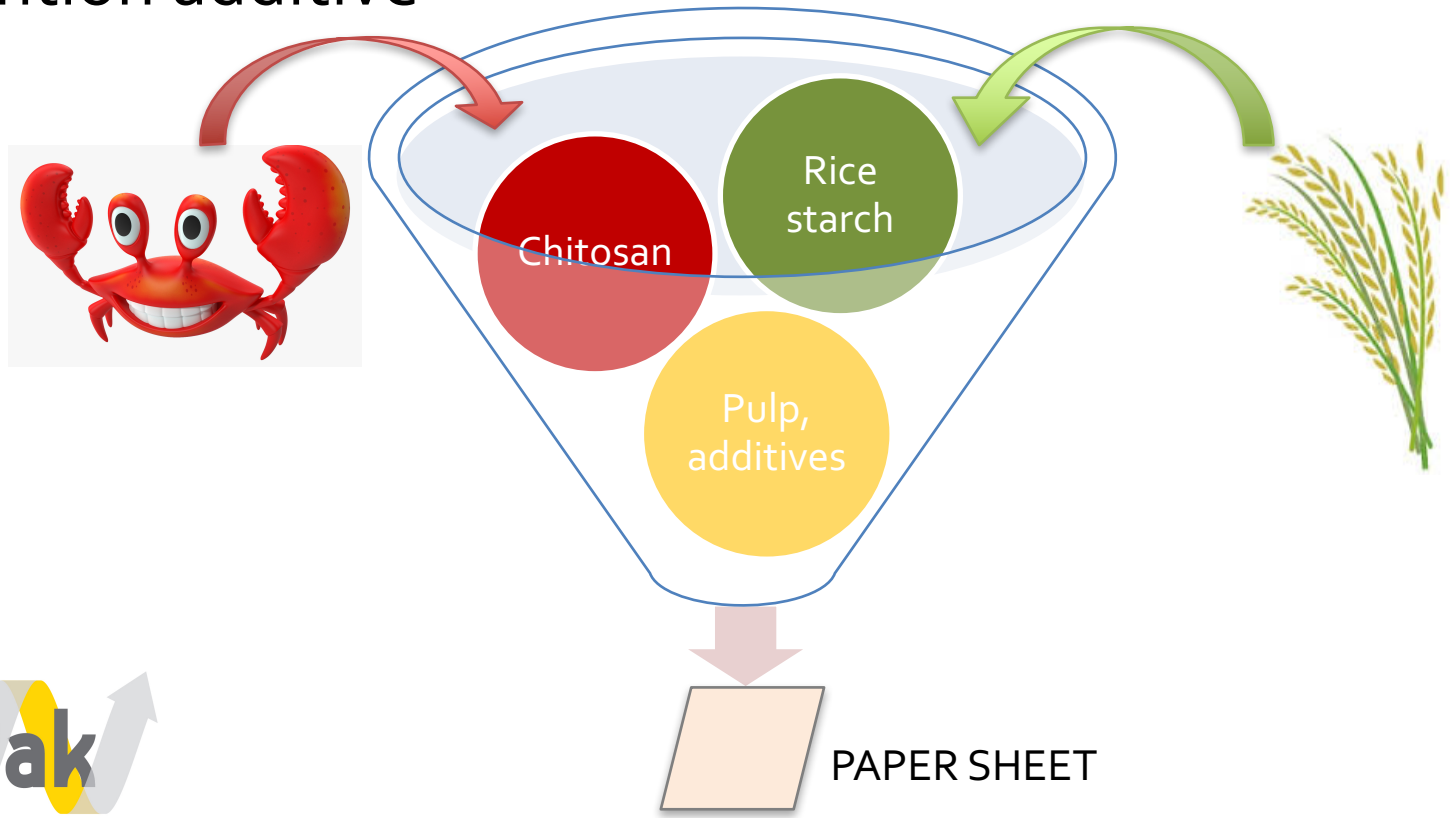
The work carried out during the STSM

Preparation of paper samples:

- we used pulp prepared from softwood (pine and spruce) and hardwood (beech), chitosan, rice starch, acetic acid, retention additive



The main objective

WHY RICE STARCH?

- Low cost, renewable, biodegradable

- Limitations due to its mechanical properties (elongation at break) and efficient barriers

- Development of the improved properties of rice-starch based films and coatings ⟹ modifying starch and/or incorporating other materials

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The main objective

WHY CHITOSAN?

- Relatively low cost, widespread, great ability to form films and coatings
- Highly impermeable to oxygen
- Good tensile properties

Advantages

Rice starch

- ✓ Low cost
- ✓ Renewable
- ✓ Biodegradable

Chitosan

- ✓ Antibacterial and ant fungicidal
- ✓ Permeability to oxygen
- ✓ Tensile properties
- ✓ Ability to form films
- ✓ Waste sea food industry

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Disadvantages

Rice starch

- Limitations to mechanical properties
- poor microbial properties

Chitosan

- Yellowness
- Cracks, pinholes of films/coatings

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The work carried out during the STSM

The paper sheets were prepared using 6 different variations and concentrations of pulp, bio polymers (chitosan and rice starch) and additives.

The work carried out during the STSM

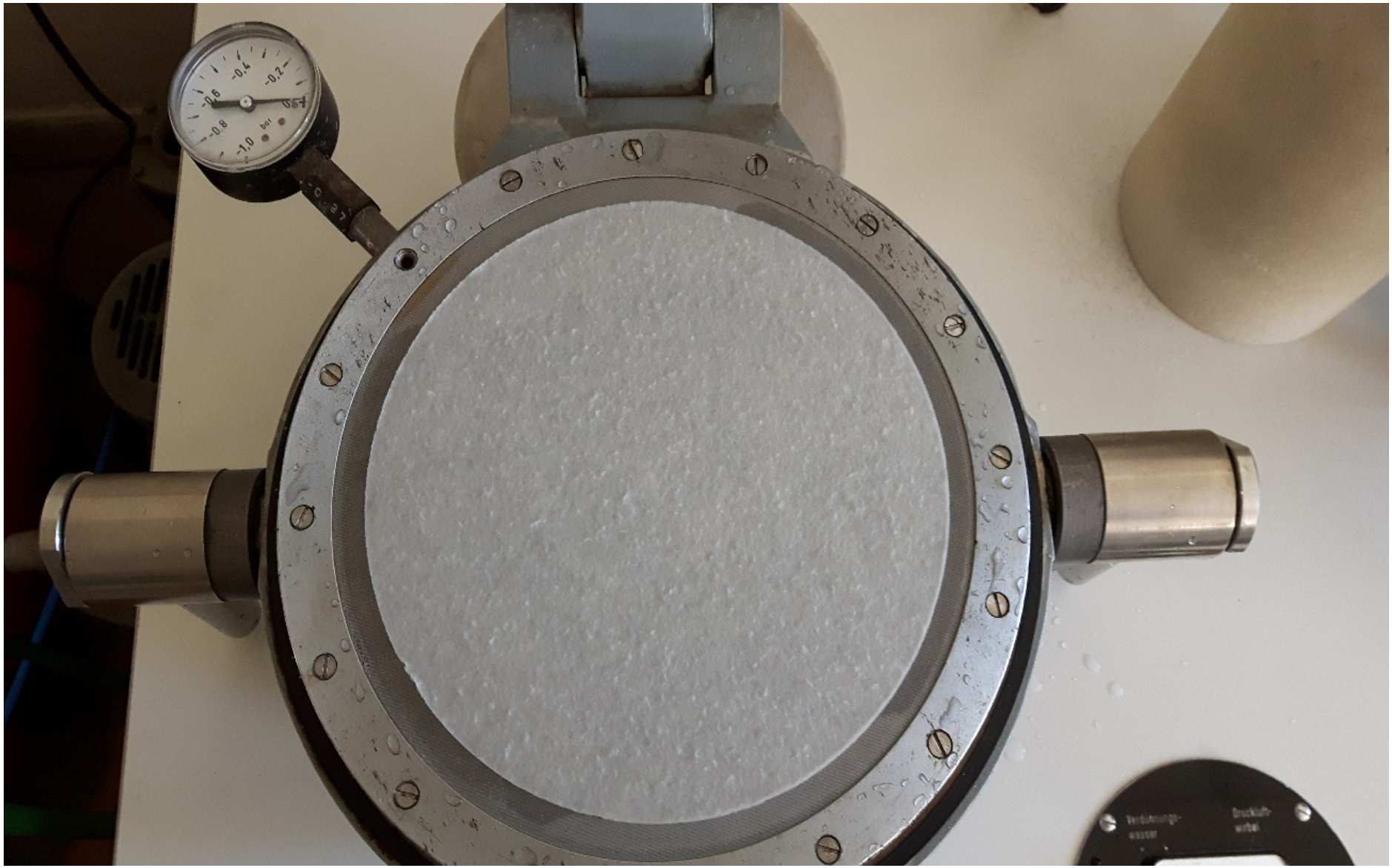
The preparation was followed with mixtures:

1) Only pulp (**Sample 1**)
2) Pulp and retention additive (**Sample 2**)
3) Pulp, 5% chitosan, retention additive (**Sample 3**)
4) Pulp, 5% of rice starch and chitosan, retention additive (**Sample 4**)
5) Pulp, 7.5% chitosan, retention additive (**Sample 5**)
6) Pulp, 7.5% of rice starch and chitosan, retention additive (**Sample 6**)

Preparation

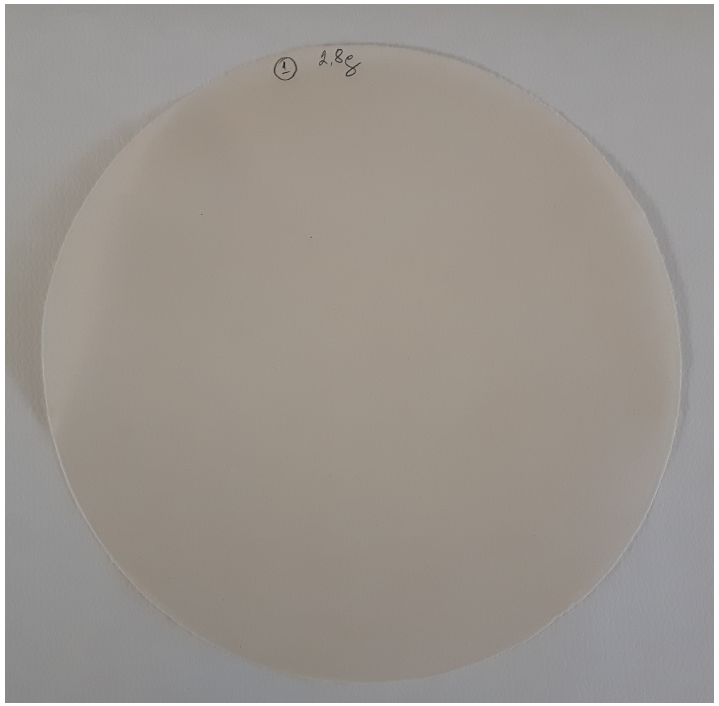
- 2000 ml of pulp
- Chitosan
- Rice starch
- Retention additive (modified cationic polyacrylamide)

10l
9
8
7
6
5
4
3
2


-0,4
-0,2
-0,6
-0,8
-1,0
bar
Verdünnungs-
wasser
Druckluft-
wirbel

The results

- Analysis of pulp
- Analysis of paper sheets



The results (Analysis of pulp)

Dewatering ($T_{700,s}$)

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
$T_{700,s}$	6.37	11.16	7.51	6.09	5.56	6.60

- the dewatering ability gives us indirect information about the flocculation ability of the paper suspension
- 7.5% chitosan (sample4), followed by the combination of 5% chitosan and starch (sample 5).
- The effectiveness of 7.5% chitosan and starch (Sample 6), over the dewatering of the suspensions is higher than that in Sample 3 (only 5% chitosan)

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The results (Analysis of pulp)

Turbidity of the white waters(T_{NTU})

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
T_{NTU}	18.50	21.60	16.20	15.60	13.90	16.10

- the results are similar to those for the dewatering ability
- Sample 5 (7.5% chitosan)-achieved the best results
- Higher turbidity of Sample 2: is probably due to the large molecular weight of the modified polyacrylamide and for this combinations of softwood and hardwood pulp the retention additive should be with lower molecular weight, so that the obtained flocks to be smaller.

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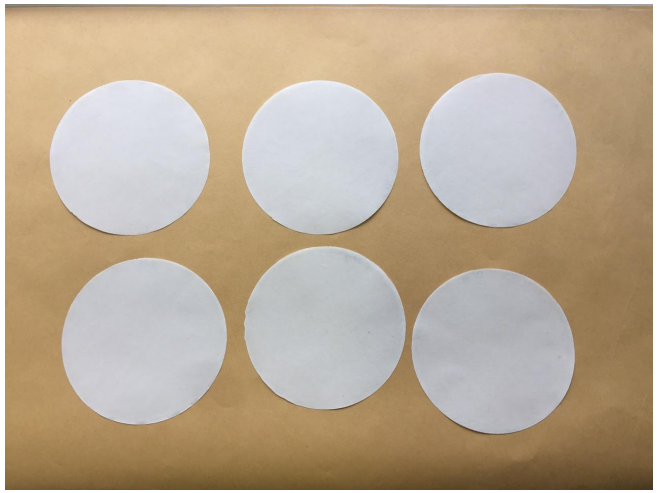
The results (Analysis of paper sheets)

- Grammage
- Thickness
- Specific volume
- Density
- Smoothnes

- Air permeability
- Bending resistance
- Water retention (Cobb value)
- Color diference
- Surface analysis (SEM)



GRAMMAGE, THICKNESS, SPECIFIC VOLUME, DENSITY

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Grammage [g/m²]	80	80	80	80	80	80
Thickness [mm]	0.084	0.095	0.091	0.090	0.095	0.096
Specific surface [m³/g]	0.0011	0.0012	0.0011	0.0011	0.0012	0.0012
Density [g/m³]	952.38	842.11	879.12	888.89	842.11	833.33

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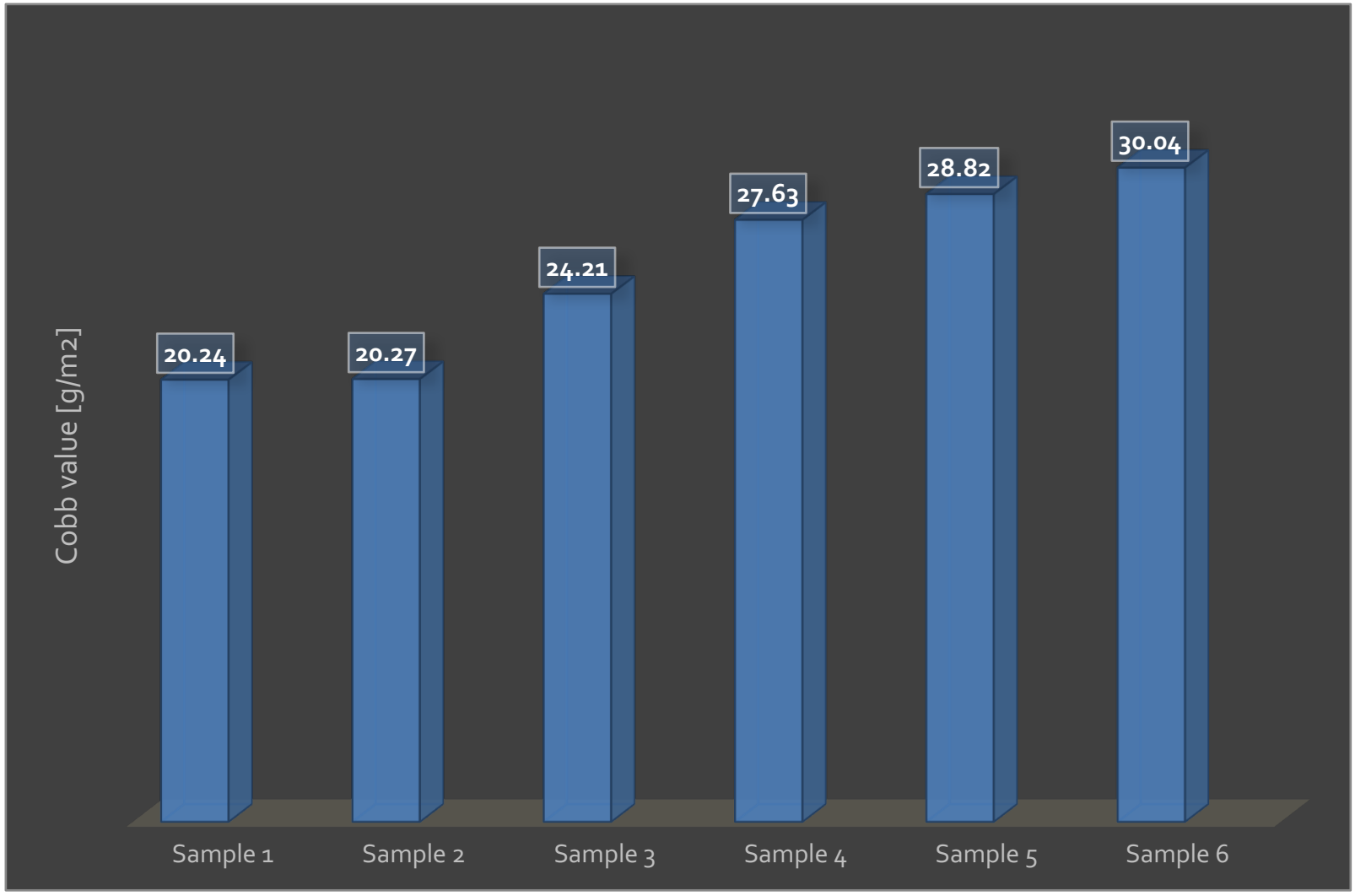
WATER ABSORPTIVNESS-COBB VALUE



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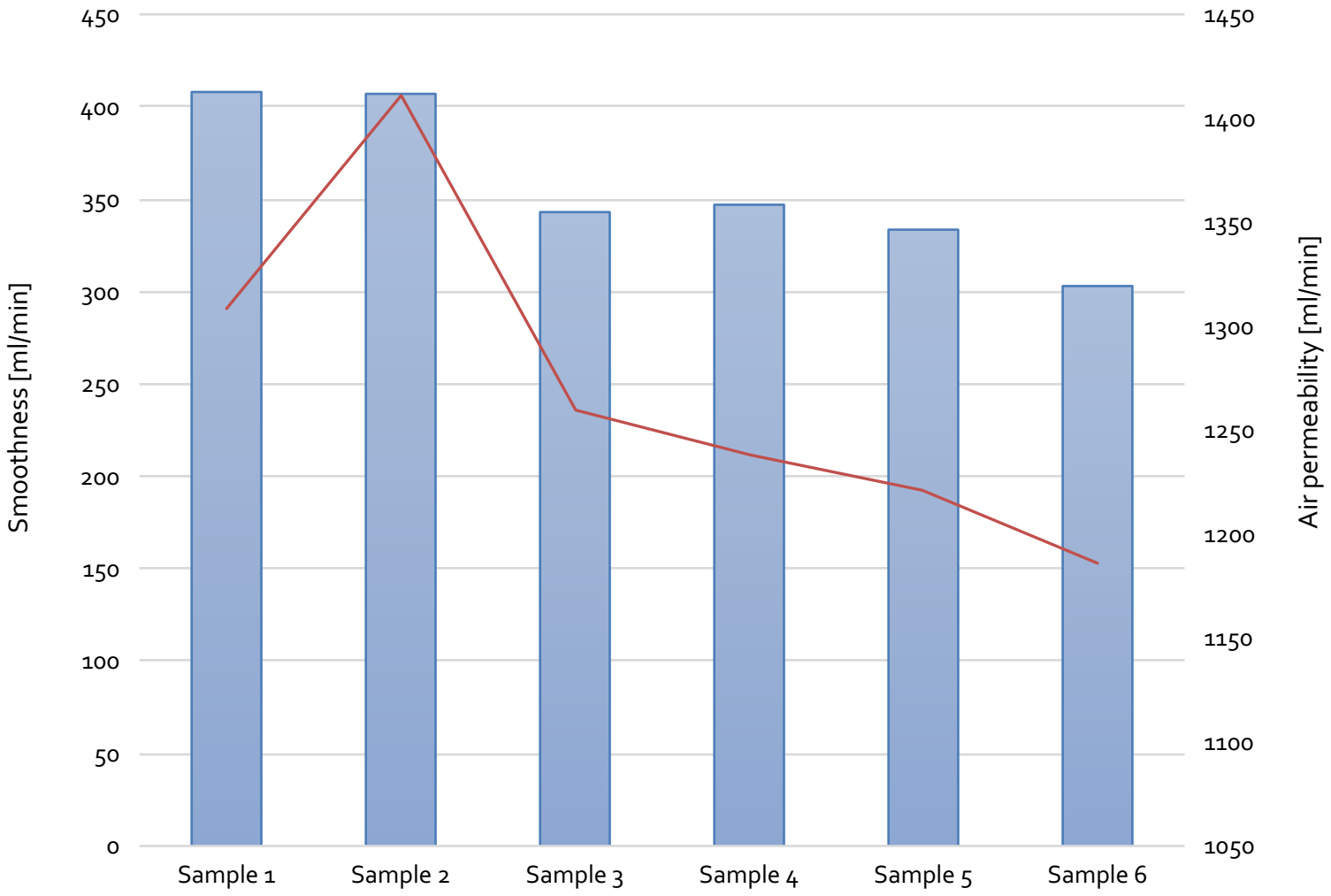
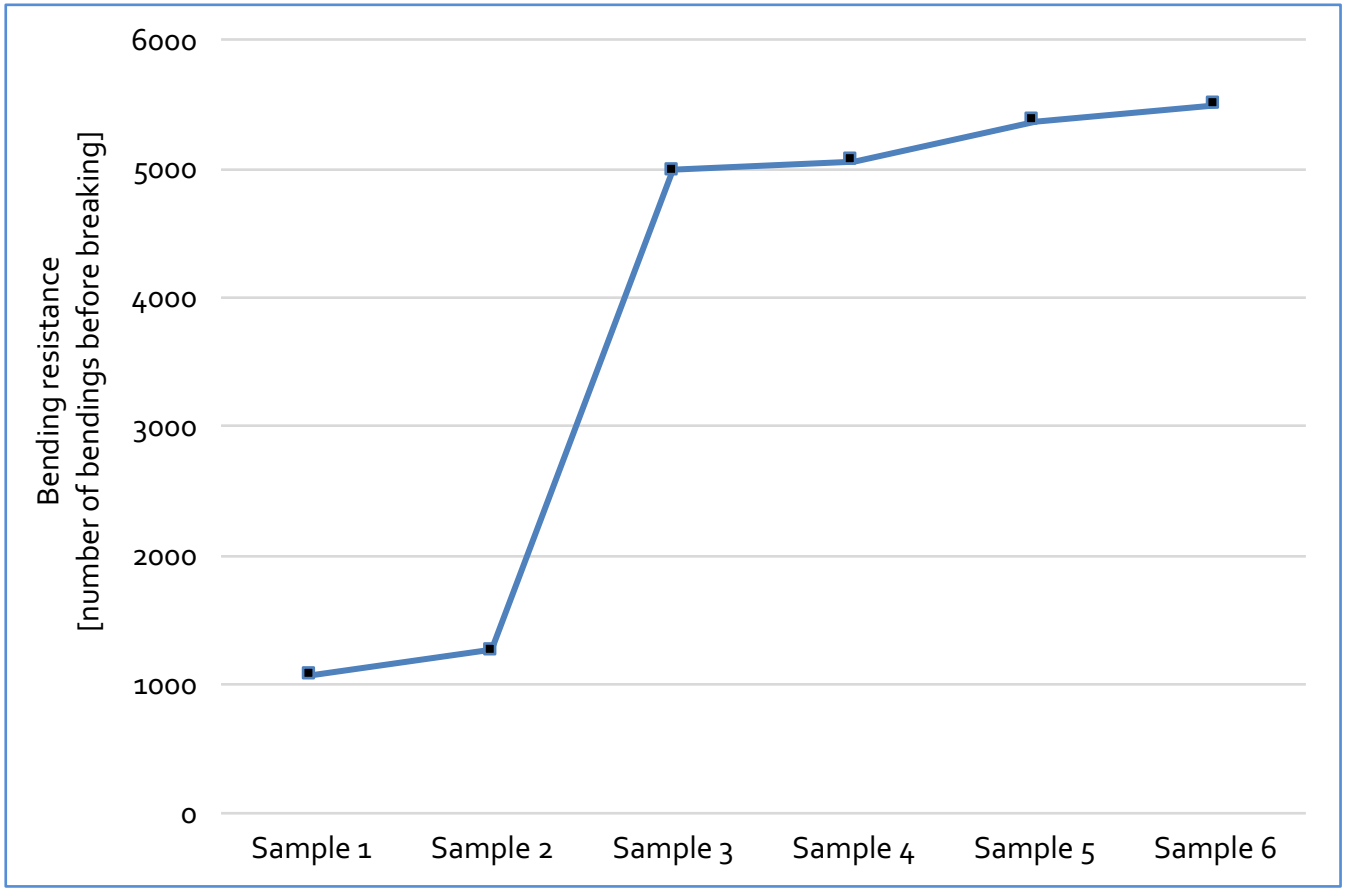
SMOOTHNES AND AIR PERMEABILITY



BENDING RESISTANCE AND COLOUR DIFFERENCE

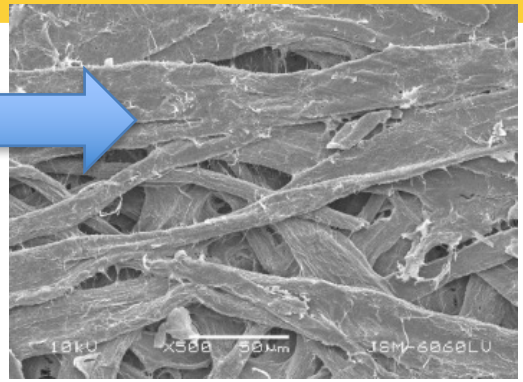


COLOUR DIFFERENCE (ΔE)

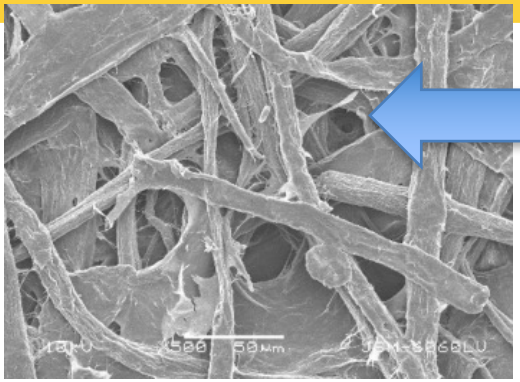
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
ΔE	/	0.39	1.86	1.27	1.89	1.55

SURFACE ANALYSIS-SCANNING ELECTRON MICROSCOPE (1000x magnification)

Only pulp



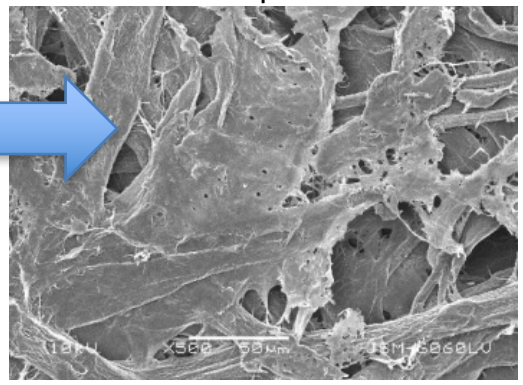
Sample 1



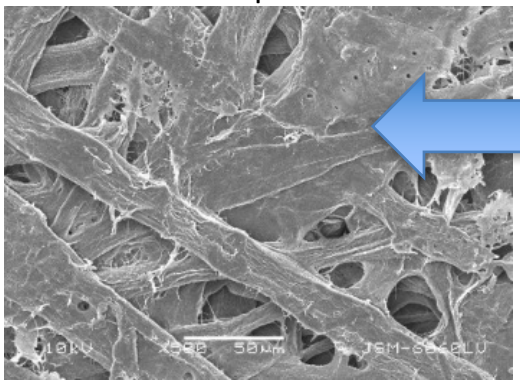
Sample 2

Pulp and retention additive

Pulp, 5% chitosan, retention additive



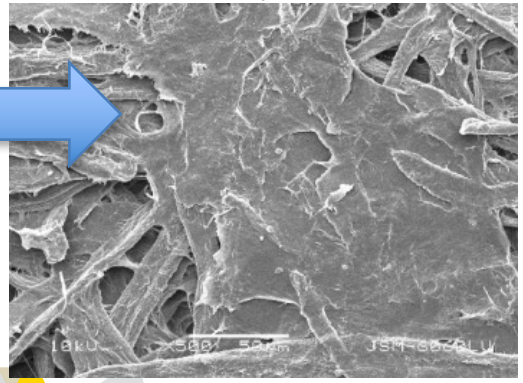
Sample 3



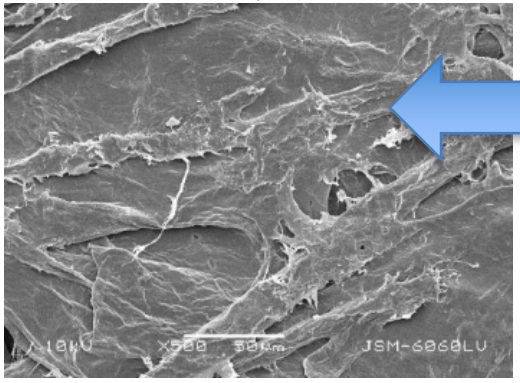
Sample 4

Pulp, 5% of rice starch and chitosan, retention additive

Pulp, 7.5% chitosan, retention additive



Sample 5



Sample 6

Pulp, 7.5% of rice starch and chitosan, retention additive

Conclusions

- It was proven that the increase of chitosan and rice starch as fillers in paper tends to increase bending resistance, smoothness and decrease air permeability
- This argument is supported by SEM results
- The addition of chitosan and rice starch decreased water absorptiveness
- 5% and 7,5% of bio polymers colour difference was detected, but not major

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Future works

- More analysis on these samples will be done: FTIR, DMA, water absorptiveness, tensile properties, grease, moisture and microbial barrier properties, which are very important for materials used in packaging field.

- The final results will also help to produce new materials, developed at this visit and to research further within ActInPak action.

- Future collaboration with the host University of Chemical Technology and Metallurgy, Department of Pulp, Paper and Printing Art in Sofia

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COST ACTION FP1405 ACTINPAK, THANK YOU FOR YOUR SUPPORT!

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