ActInPak COST FP1405
Spring Meeting 2016

DEVELOPMENT OF NEW ACTIVE COATINGS BASED ON BIOPOLYMERS FROM RENEWABLE SOURCES

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COST FP1405

ACTIVE AND INTELLIGENT FIBRE-BASED PACKAGING – INNOVATION AND MARKET INTRODUCTION

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cost
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

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Summary

- (Bio)polymers in food packaging materials - recent trends
- Degradation processes in foods - solutions
- Materials: alginate and lignosulfonate as components of active coatings/films
- Rheology of film-forming solutions
- Microscopy (SEM, AFM) and optical properties of the thin films
- Evaluation of antioxidant effect in the obtained coatings

Polymers in food packaging

Classical packaging materials
synthetic polymers
(PE, PP, PET, PVC)

Advantages:

- wide availability
- relatively low cost
- mechanical performance
- barrier properties (O_2, CO_2)
- thermal protection etc

Drawbacks:

- non-biodegradable
- non-recyclable
- biological contamination

Ecological problems

Recent trends/requirements

- Natural
- Biodegradable/Recyclable
- Sustainable
- Biocompatible
- Non-toxic
- Protection
- Preservation
- Multifunctionality (active/intelligent)

positive effects

- **Extended shelf-life**
- **Food quality**
- **Consumer health**

Degradation processes in foods

O_2 → • lipid oxidation
• microrganisms growth
• enzymatic browning
• vitamin loss → ➢ quality loss
➢ shelf-life limitation

Antioxidants:

- ascorbic acid
- citric acid
- N-acetylcysteine
- glutathione
- essential oils

- **LIGNIN** - effective free radical scavenger →
  - animal husbandry,
  - pharmaceutical and
  - food processing industries

Why ?

Alginate

- structural component in the cell wall of marine brown algae (*Phaeophyceaea*)
- linear polysaccharide –copolymer of (1-4) linked β-D-mannuronic and α-L-guluronic acid residues
- gelling, viscosifying, stabilizing properties
- high viscosity in aqueous solutions, forming homogeneous films

Lignin/ammonium lignosulfonate

- one of the main components of plant cell walls; the second most abundant biopolymer after cellulose
- typical lignin derivative, produced through the sulfite pulping process as a by-product in the production of cellulose
- anionic polyelectrolyte (hydrophilic sulfonate groups (SO_3^-))
- polyphenolic structure - antioxidant properties

- **renewable**
- **biodegradable**
- **biocompatible**
- **non-toxic**

Active coatings/films

Rheological behavior of film forming solutions

- ❑ steady shear
- ❑ dynamic oscillatory measurements

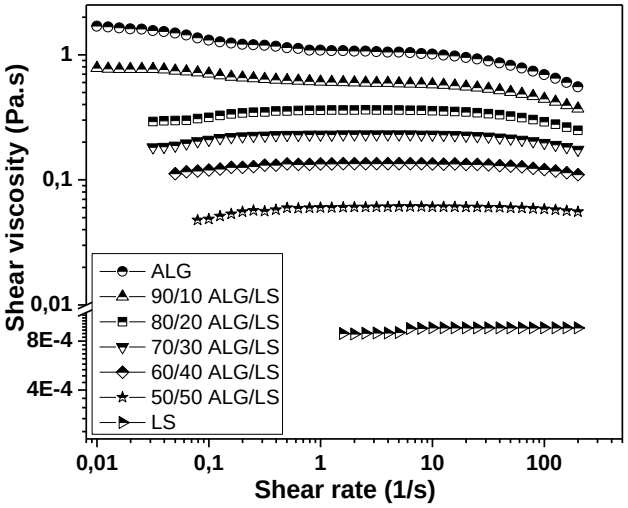
- Anton Paar Physica MCR 301 Rheometer (Anton Paar, GmbH, Germany)
- cone-plate geometry 50 mm diameter with a 1° angle
- Peltier heating system for accurate temperature control.
- measurements performed at 25 °C

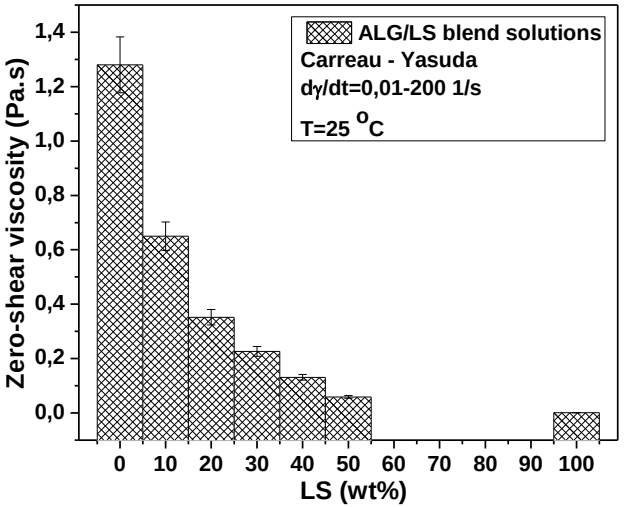
- to assess the influence of blend solutions composition on their flow behavior and viscoelastic response

- the rheological properties of polymer solutions can be decisive for the development of packaging films by bringing essential information about the viscoelastic response and processability conditions.

Steady shear flow behavior

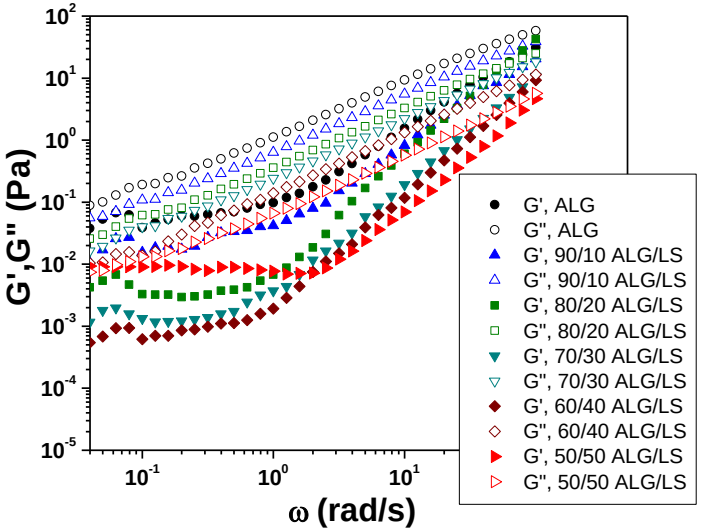
- **Rotational measurements at 25 ºC**

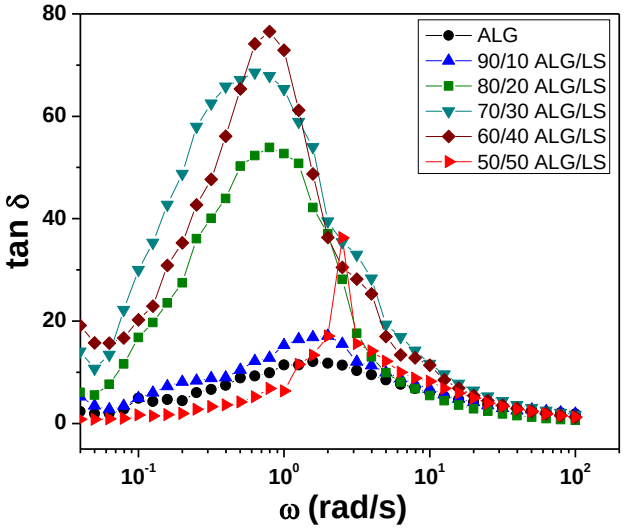




Dynamic viscoelastic behavior

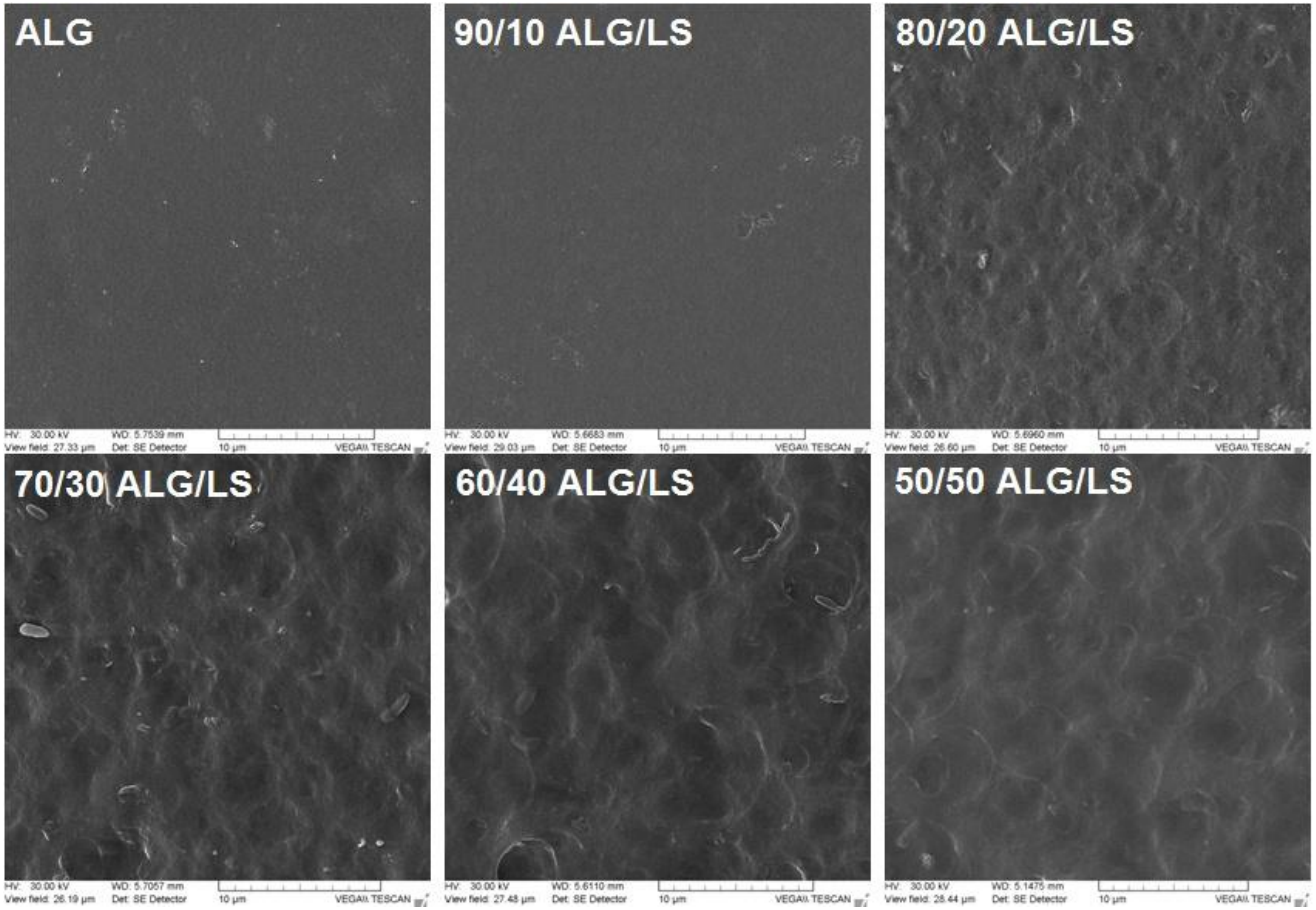
Oscillatory frequency sweep tests





$\tan \delta = G''/G'$

Morphological aspect (SEM) of ALG/LS thin films

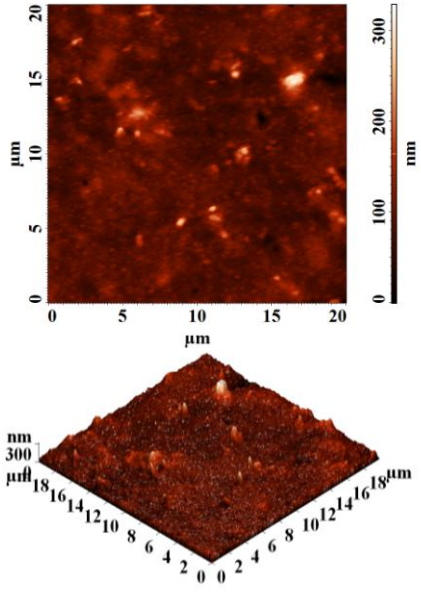


- modified morphology depending on composition

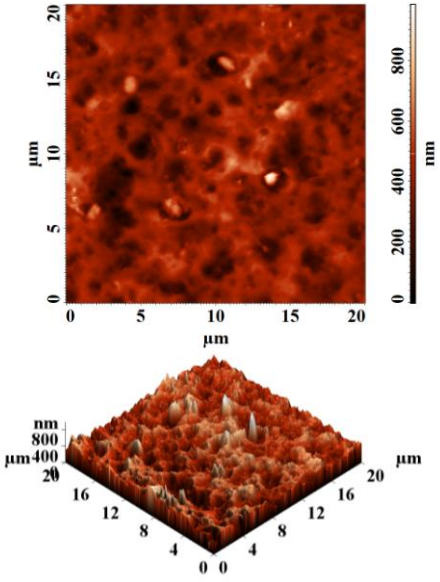
Surface topography of ALG/LS thin films

- Solver Pro-M Scanning Probe Microscope (NT-MDT, Zelenograd, Russia) in atomic force microscopy (AFM) configuration

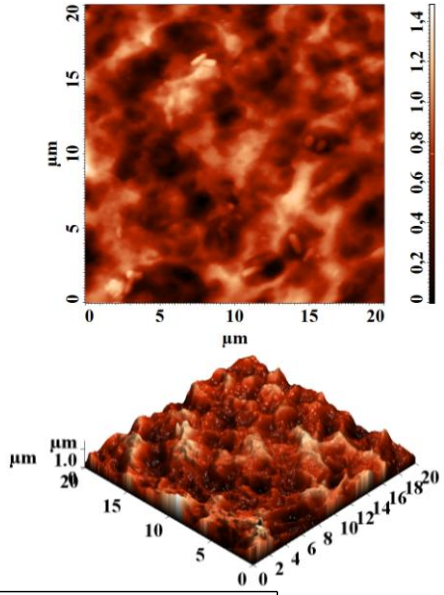
100/0 ALG/LS



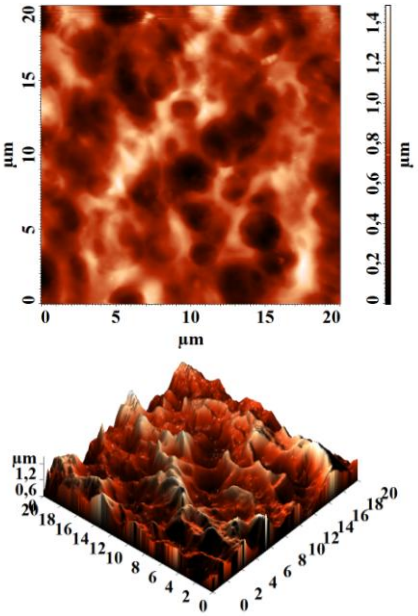
80/20 ALG/LS

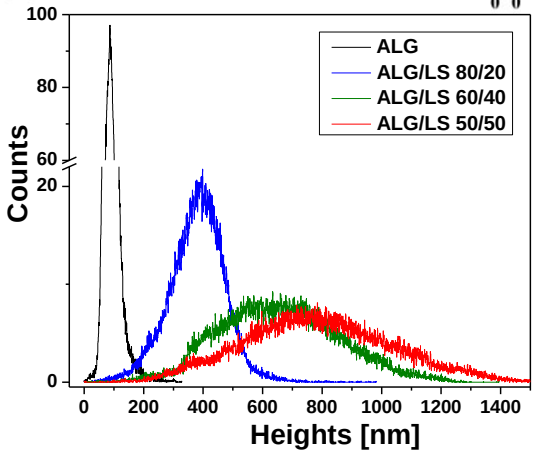


60/40 ALG/LS



50/50 ALG/LS





Optical properties of ALG/LS thin films

- Cary 60 UV-VIS spectrophotometer (Agilent Technologies)

$$Opacity = Abs_{600} / x$$

where Abs_{600} - absorbance recorded at 600 nm
x - film thickness (mm)

Sample ALG/LS	Wavelength (nm)								Opacity*
	200	280	350	400	500	600	700	800	
ALG	0.14	57.46	74.55	80.67	85.38	87.12	91.31	90.36	2.67 (0.005)
90/10	0.025	5.46	43.95	62.03	76.3	82.13	87.91	87.9	3.82 (0.02)
80/20	0.024	0.46	16.38	37.07	58.88	71.35	80.67	82.22	5.72 (0.02)
70/30	0.024	0.16	18.3	34.19	50.7	61.23	70.47	73.58	13.89 (0.06)
60/40	0.022	0.14	15.46	30.76	47.89	57.89	67.42	69.64	15.92 (0.03)
50/50	0.019	0.12	13.06	28.84	44.67	54.95	63.38	66.07	17.48 (0.03)

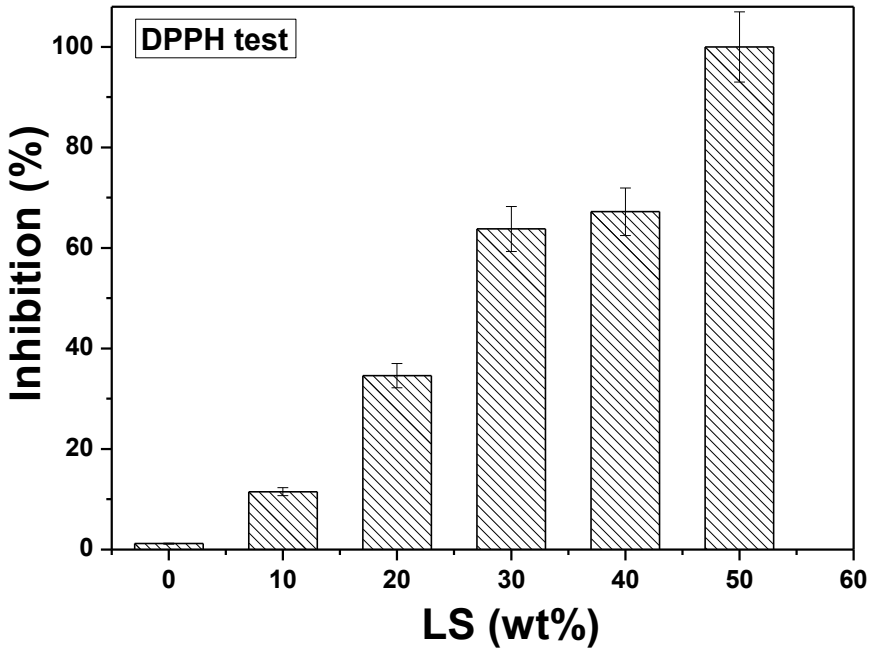
Antioxidant activity

- DPPH (2,2-diphenyl-1-picrylhydrazyl) assay – measurement of radical scavenging activity (RSA) expressed as percent inhibition of DPPH radicals by measuring the absorbance at 517 nm :

$$Inhibition\,\% = \frac{A_0 - A_1}{A_0} \times 100$$

where A_0 - absorbance of the blank solution without ALG/LS film

A_1 - absorbance of the sample solution



- Increased LS content leads to enhanced antioxidant activity of the blend films.

Conclusions

- Alginate/lignosulfonate blend solutions and the obtained thin films with different compositions have been prepared and studied comparatively.
- The rheological investigation of film forming solutions showed an almost Newtonian behavior on a wide shear rate range, with significant decrease in viscosity as LS is added in composition.
- The viscoelastic liquid-like behavior (G”>G’) was evidenced for the compositions tested.
- SEM and AFM investigations evidenced the decrease of homogeneity and smoothness of the films surface by adding LS in composition, while UV-VIS spectroscopy results obtained suggest that ALG/LS blend films can potentially retard lipid oxidation induced by UV light in food products.
- The DPPH test showed that lignosulfonate presence offers enhanced radical scavenging/ antioxidant activity to the ALG/LS films prepared.
- These films have potential for application as edible coatings or coating films for short shelf life food products.

Thank you for your kind attention!

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