ASSOLOMBARDA
Confindustria Milano Monza e Brianza

Coatings innovativi per migliori prestazioni e maggiore sostenibilità dell'imballaggio flessibile per alimenti

Biopolimeri e nanocompositi applicati come sottili rivestimenti per estendere la shelf life di prodotti deperibili e ridurre peso e impatto ambientale del flexible packaging

Speaker
Luciano Piergiovanni

30 novembre 2016

Sara Limbo, Stefano Farris – PackLAB, Università degli Studi di Milano

ASSOLOMBARDA Confindustria Milano Monza e Brianza
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DEPARTMENT OF FOOD, ENVIRONMENTAL AND NUTRITIONAL SCIENCES

www.packlab.unimi.it

PackLAB
UNIMI Food Packaging Laboratory

The UNIMI Labs

Established in order to create a "brand" that can help to identify specific research activities, particularly towards potential stakeholders; in order to implement an effective organizational arrangements for the coordination of research activities.

The UNIMI Labs identify a group of professors/researchers structured within the same Department that intend to collaborate on a specific research topic. Laboratories may have a scientific manager ("Head") and each professor or researcher can join only one Laboratory. The laboratories are not structures with management autonomy.

PACKLAB LINKS and CONNECTIONS

We have several collaborations with other Universities and Research Centres around the world:

Department of Food Science
Rutgers University New Brunswick, New Jersey

Division of Life Sciences
Kyungnam University Masan South Korea

Tianjin University of Science and Technology Hexi district, Tianjin, China

Department of Food Science and Technology, Kasetsart University

Agropolymers Engineering and Emerging Technologies Montpellier University France

INRA UMR Science de l'aliment et de l'emballage (INRA-CNAM-ENSIA)
MASSY CEDEX France

Bordeaux University FR - Biopolymers & bio-based materials LCPO, UMR CNRS 5629 -IPB/ENSCBP

Centro Politécnico Superior de Ingenieros Universidad de Zaragoza Spain

Facultade de Farmacia Universidade de Santiago de Compostela Spain

Fraunhofer-Institut für Verfahrenstechnik und Verpackung IVV in Freising

NOFIMA, Norwegian Institute of Food, Fisheries and Aquaculture Research –Packaging Group

PACKLAB LINKS and CONNECTIONS

We have/had many partnerships with food and packaging companies as well as with Industrial Associations:

Cryovac Sealed air
Goglio spa
Sirap Gema Group
AMB packaging
SAES- Metalvuoto
SIG COMBIBLOC srl
CSI spa IMQ Group
ITP, Industria Termoplastica Pavese
Carta Stampa……...

Ferrero
Barilla
Rovagnati
Lavazza
Gran Milano
Naba carni
Specchiasol
Hilly cafè *……*

GIFLEX The group of Italian Flexible Materials Producers

SSCC The experimental Centre for paper and board

IPACKIMA International Exibition for Processing, Packaging & Material handling

PVC Information Centre

UNIONPLAST – Plastiservice

AIIPA Associazione Italiana Industrie Prodotti Alimentari

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PACKLAB research: focus on coating technology

Coatings scale up at our disposal

Laboratory scale

Pilot scale

Industrial level

S. Farris, L. Piergiovanni . 2012 Advances in coating technologies for food and beverage packaging materials. In: Emerging Food Packaging Technologies (2012),K. Yam and D.S. Lee (Eds.). Woodhead Publishing Ltd, Oxford, UK. pp. 274

PACKLAB research: focus on coating technology

Massive deposition

Massive deposition of one specific substance:

wax on paper and board, PVDC or Nitrocellulose onto cellophane and polyolefin, aluminum, PVOH, acrylic, and other chemicals.

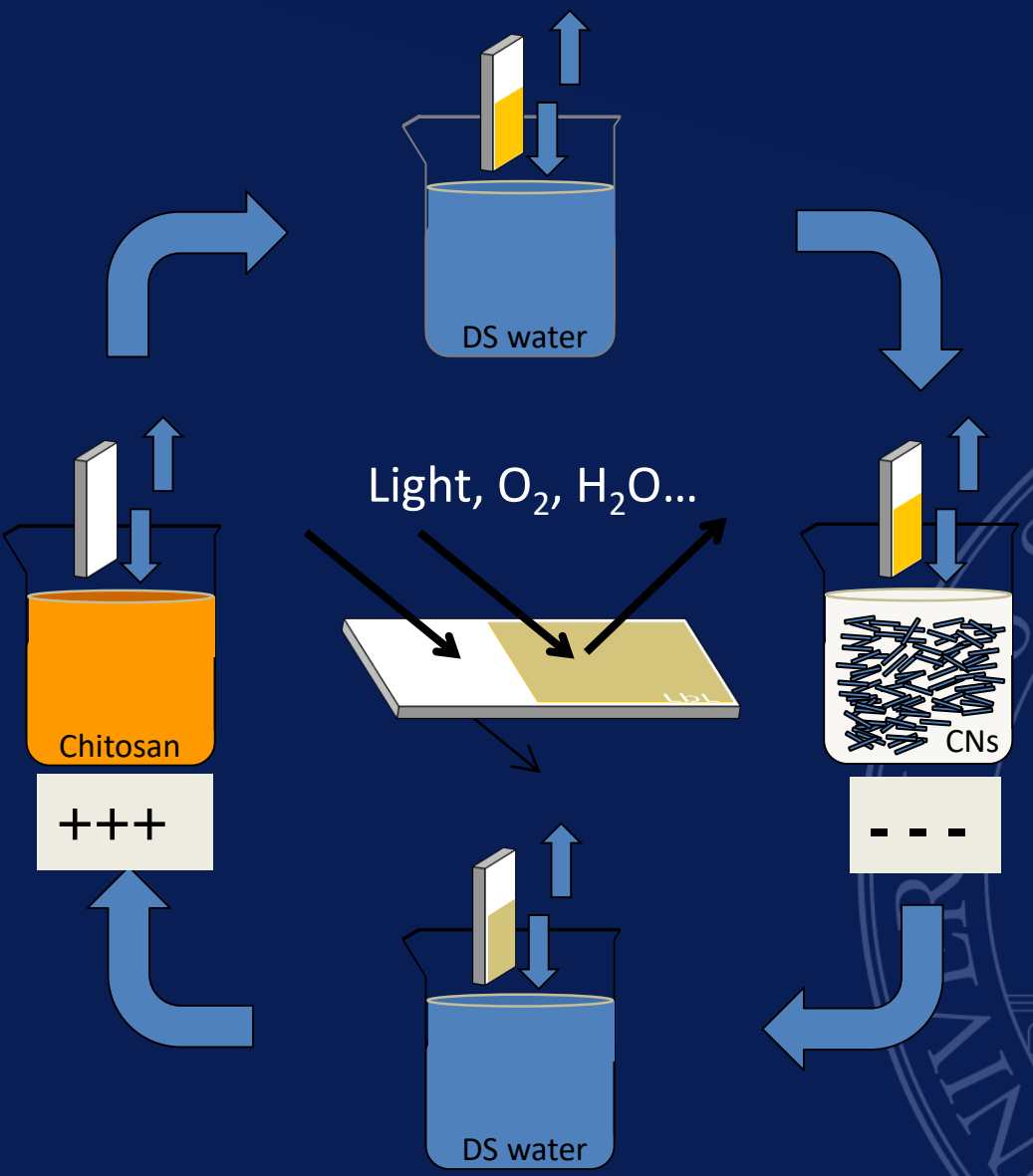
More recently also bio-based materials (starch, chitosan nanocellulose, pullulan,…)

In situ coating generation

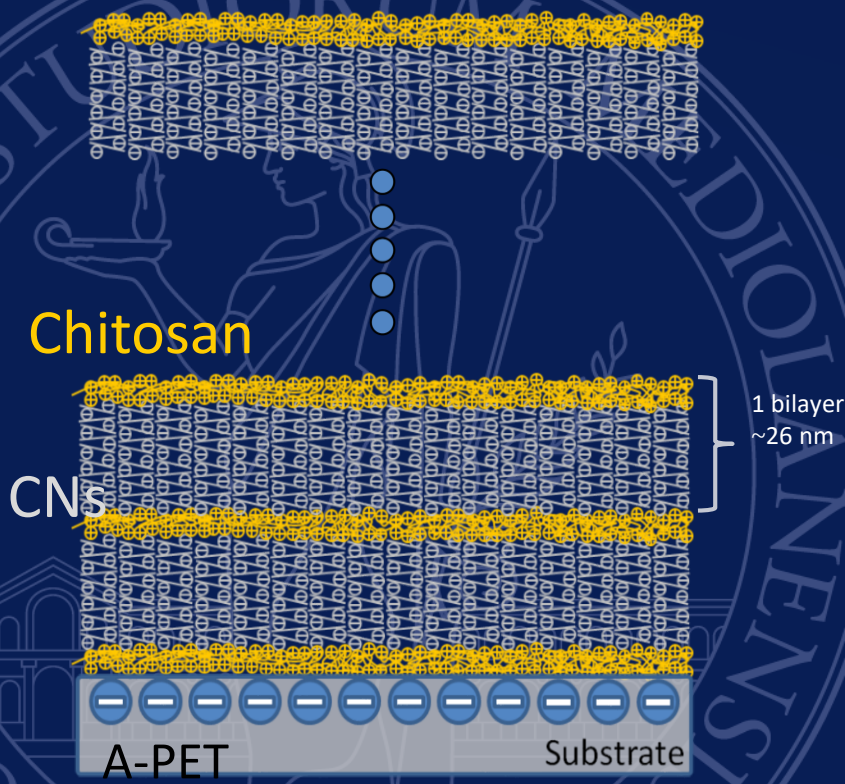
In situ generation of the coating specialty (hybrid coatings, nano-composites, layer by layer assemblies, reactive coatings, sensors….)

S. Farris, L. Piergiovanni . 2012 Advances in coating technologies for food and beverage packaging materials. In: Emerging Food Packaging Technologies (2012),K. Yam and D.S. Lee (Eds.). Woodhead Publishing Ltd, Oxford, UK. pp. 274

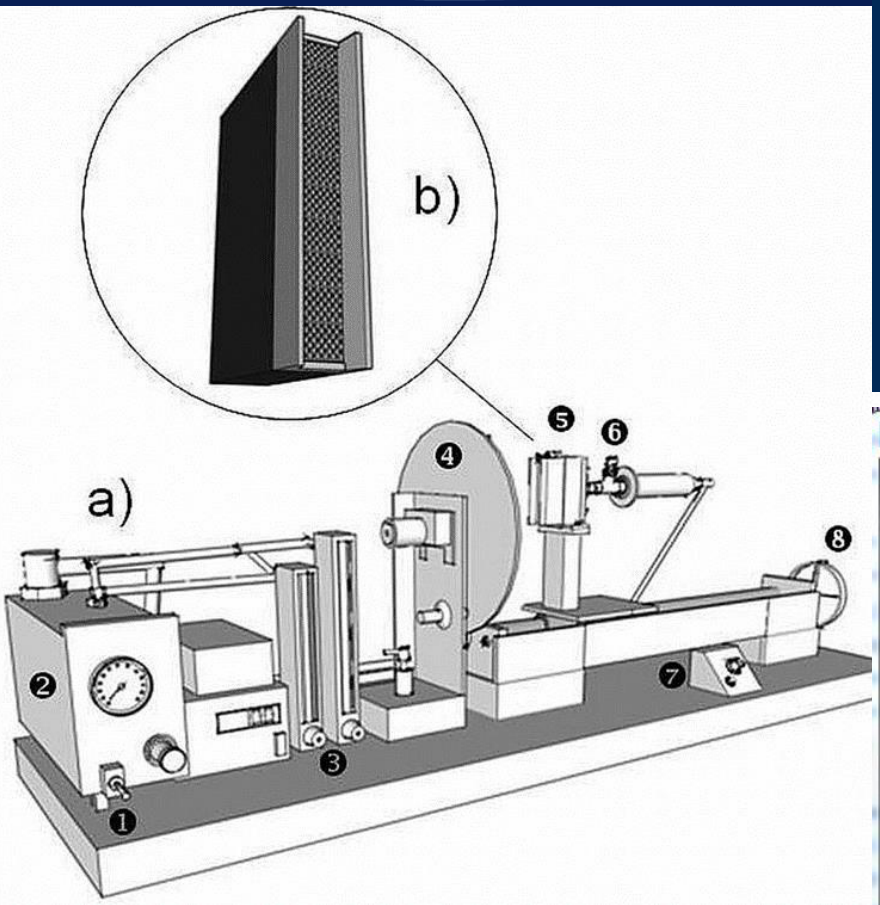
PACKLAB research: focus on in situ coating generation



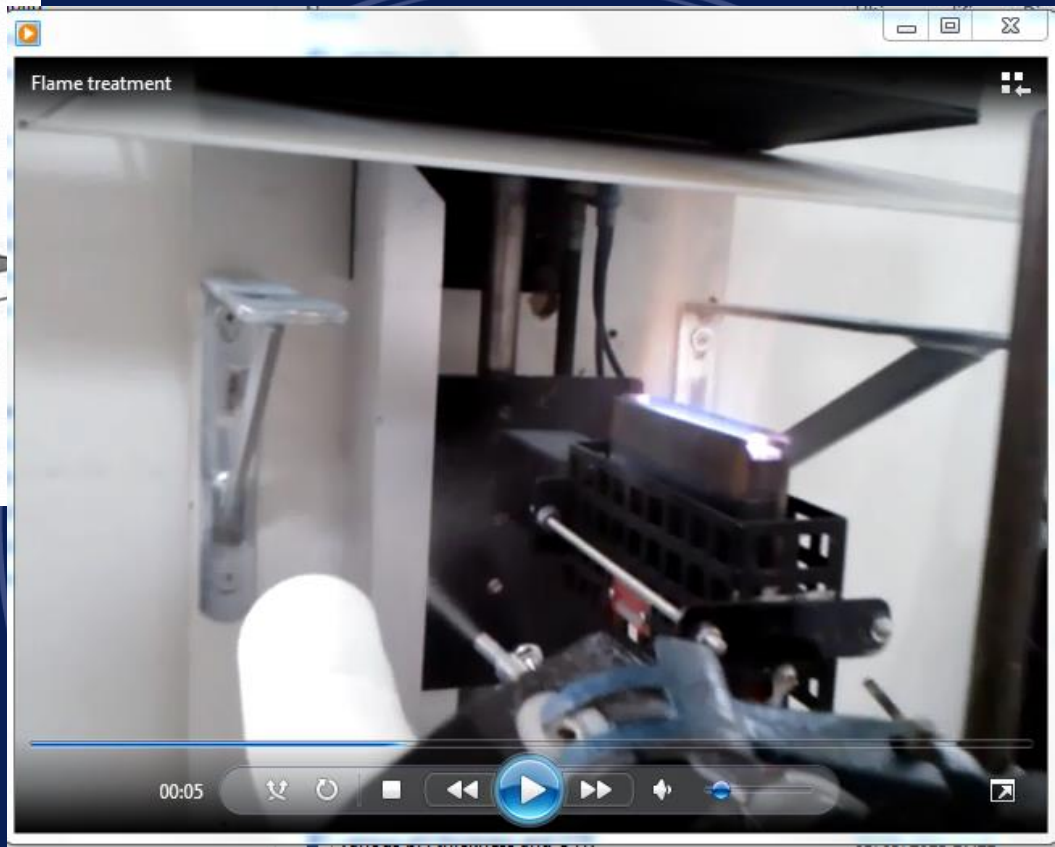
Coating by Layer by Layer assembly



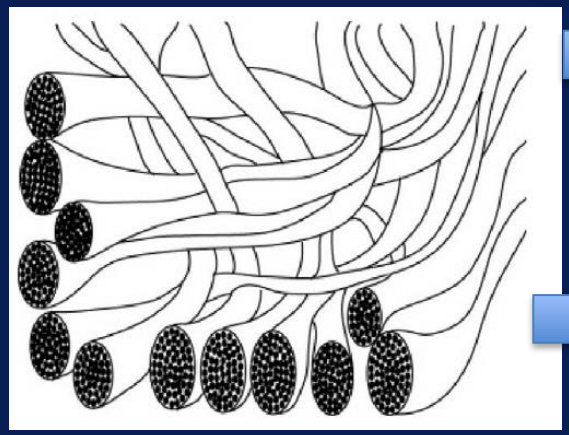
PACKLAB research: focus on in situ coating generation



a) Flame treater: 1 – manual start; 2 – gas/air mixer; 3 – gas and air flow meters; 4 – rotating sample holder; 5 – ribbon burner; 6 – gas/air mixture sampling valve; 7 – sample holder speed control (relay); 8 – flame-to-sample gap manual adjuster. (b) Magnification of the ribbon burner.



PACKLAB research: focus on nanocellulose

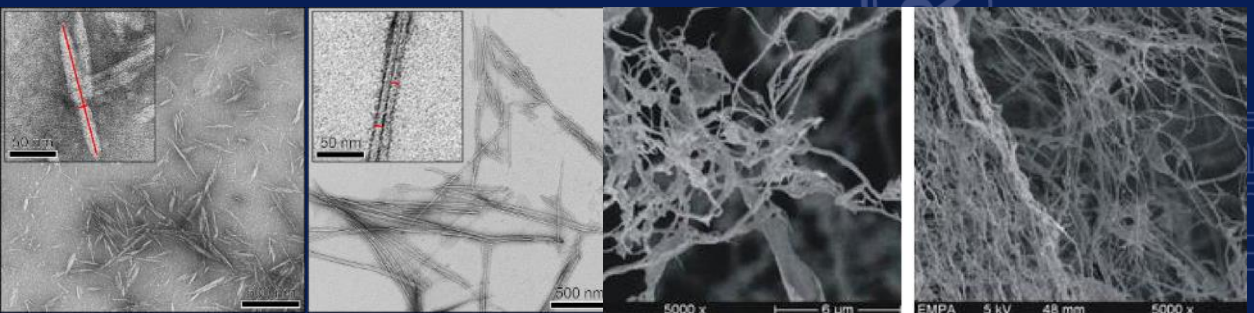


Single fiber network

Cell. Nanocrystals (CNC)

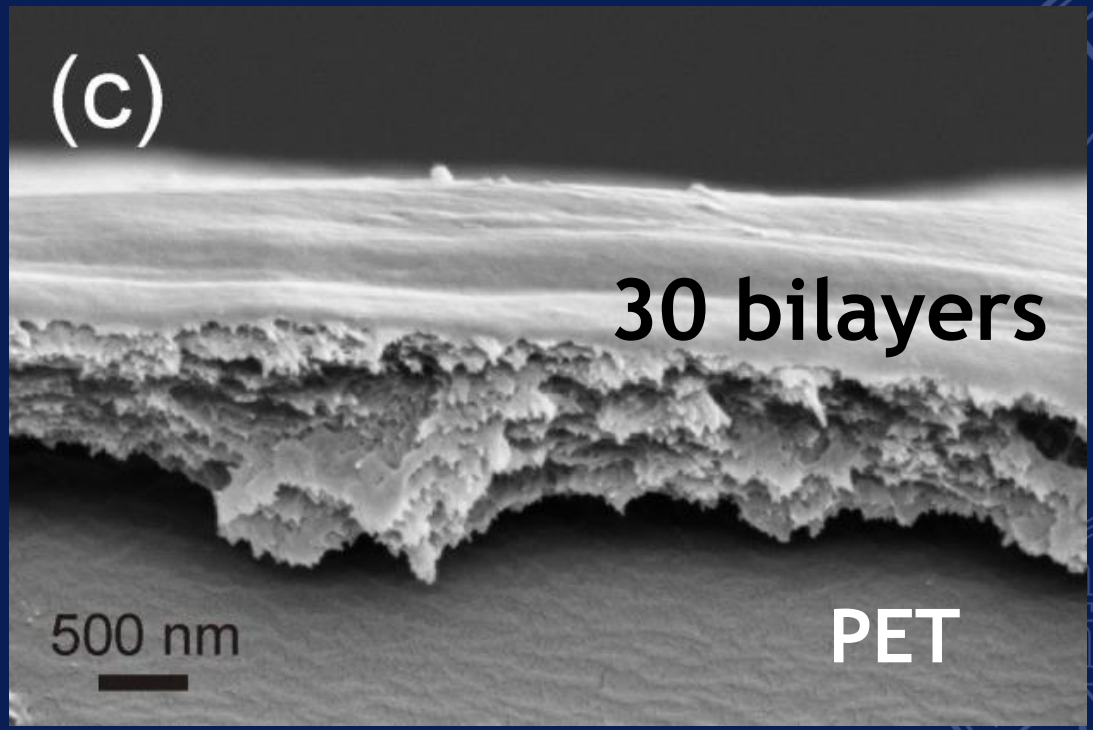
Nanofibrillated Cell. (NFC)

Li, Fei, Erika Mascheroni, and Luciano Piergiovanni. "The potential of nanocellulose in the packaging field: a review." 2015 Packaging Technology and Science 28.6 : 475-508.



PACKLAB research: focus on nanocellulose

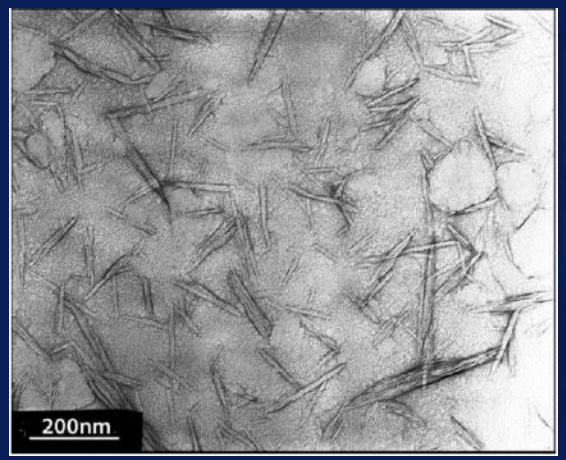
Tunable Green Oxygen Barrier through Layer by Layer assembly of Chitosan and Cellulose Nanocrystals

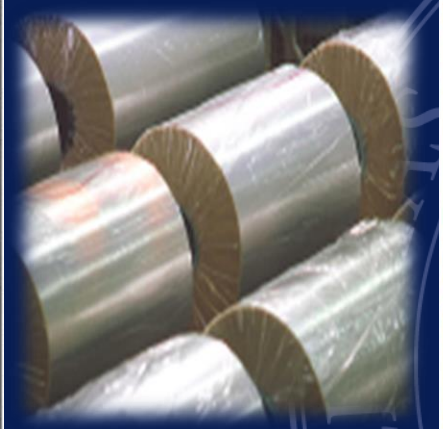


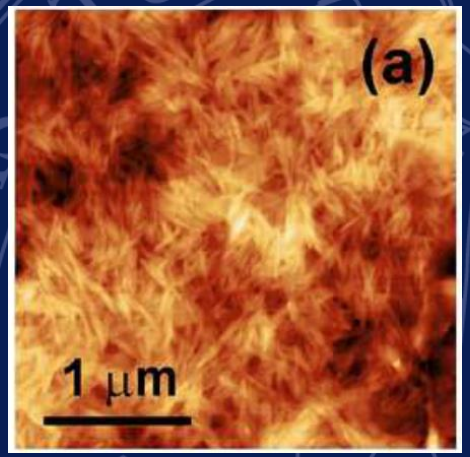
F. Li, P. Biagioni, M. Finazzi, S. Tavazzi, L. Piergiovanni. 2013 Tunable Green Oxygen Barrier through Layer by Layer Self-assembly of Chitosan and Cellulose Nanocrystals. *Carbohydrate Polymers*. 92 (2): 2128-2134

PACKLAB research: focus on nanocellulose

Multi-functional Coating of Cellulose Nanocrystals for Flexible Packaging Applications



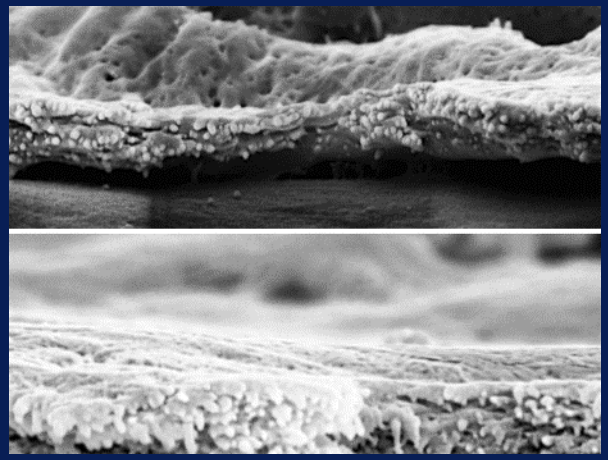


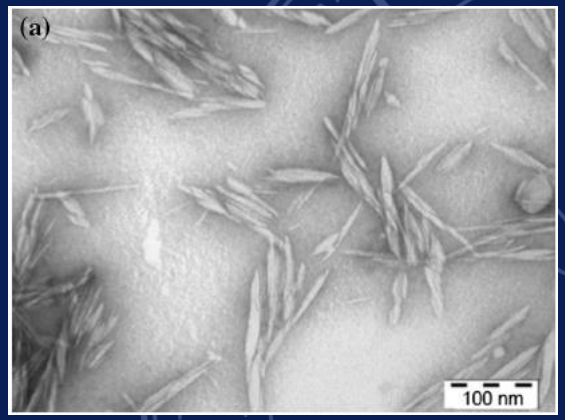


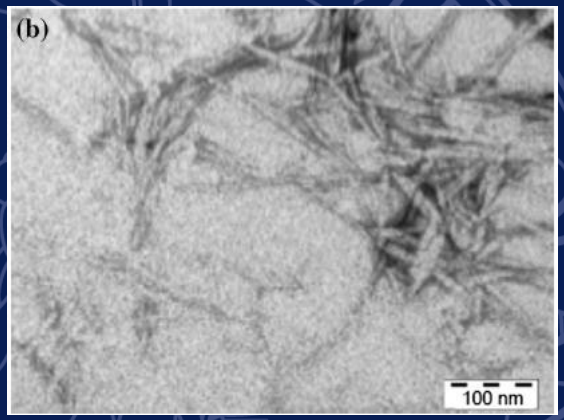
F. Li, P. Biagioni, M. Bollani, A. Maccagnan, L. Piergiovanni. 2013 Multi-functional coating of cellulose nanocrystals for flexible packaging applications *Cellulose 20* (5): 2491-2504

PACKLAB research: focus on nanocellulose

Comparison of cellulose nanocrystals obtained by sulfuric acid hydrolysis and ammonium persulfate, to be used as coating on flexible food-packaging materials.



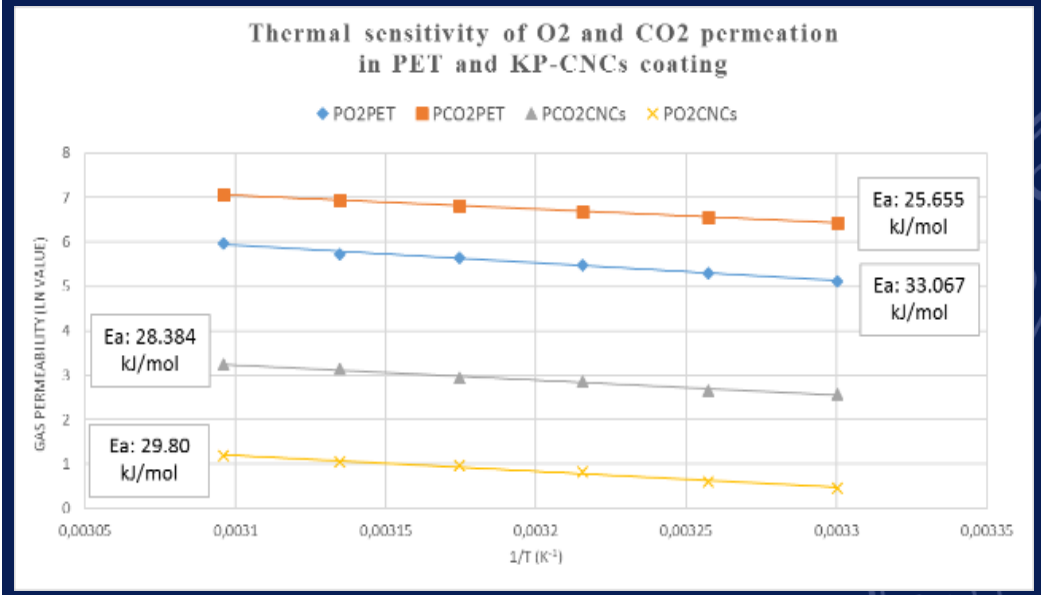




Mascheroni, E., Rampazzo, R., Ortenzi, M. A., Piva, G., Bonetti, S., & Piergiovanni, L. (2016). Comparison of cellulose nanocrystals obtained by sulfuric acid hydrolysis and ammonium persulfate, to be used as coating on flexible food-packaging materials. Cellulose, 23(1), 779-793.

PACKLAB research: focus on nanocellulose

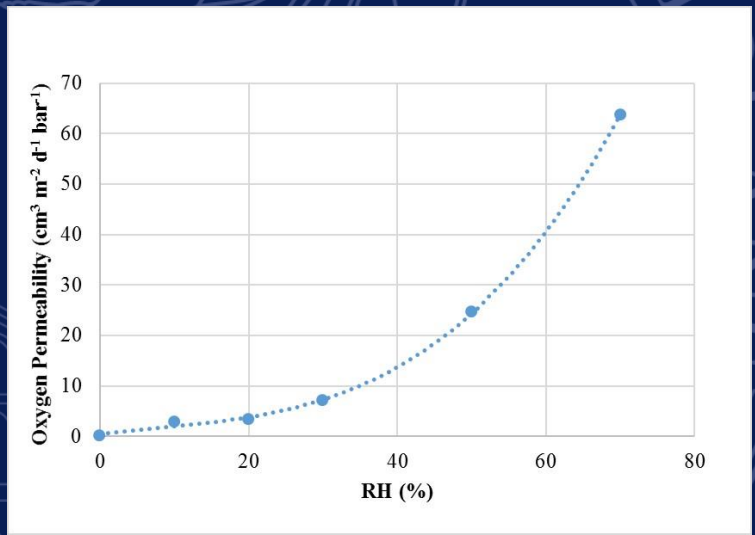
Cellulose nanocrystals from lignocellulosic raw materials, for oxygen barrier coatings of food packaging films



Rampazzo R., Alkan D., Gazzoli S., Piva G., Piergiovanni L. Cellulose nanocrystals from lignocellulosic raw materials, for oxygen barrier coatings of food packaging films. 2016 SUBMITTED to Packaging Technology and Science

Wood Pulp

Kraft Pulp



PACKLAB research: focus on functional barrier

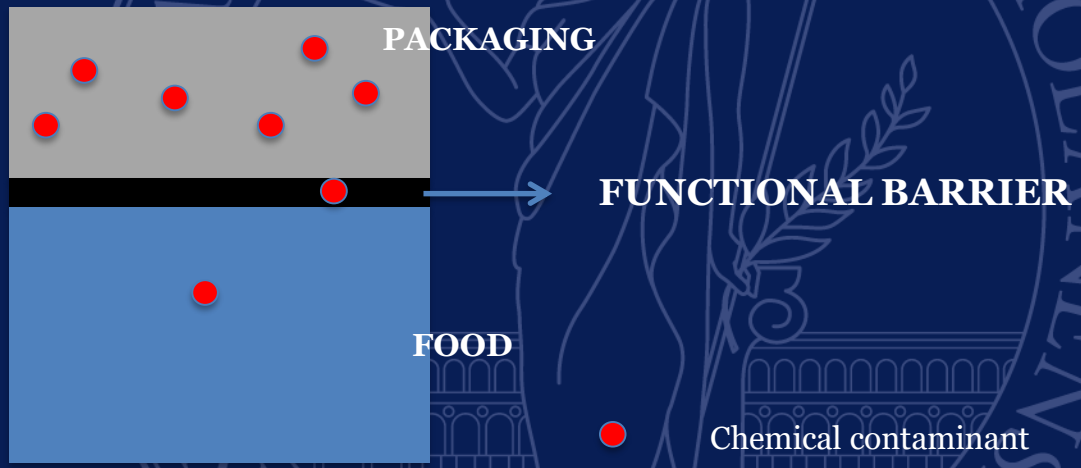
Functional barriers are multilayer structures deemed to prevent MIGRATION of some chemicals that can be released by food contact materials into food (Feigenbaum et al.)

FIELDS of APPLICATION

1. RECYCLED PAPER and PAPERBOARD
2. RECYCLED PLASTICS
3. ACTIVE PACKAGING
4. SUBSTANCES NOT APPROVED BY REGULATION

Safety

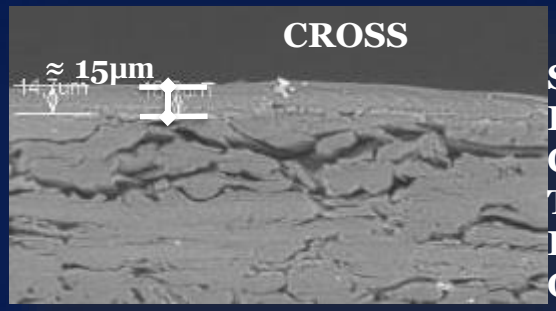
Sustainability

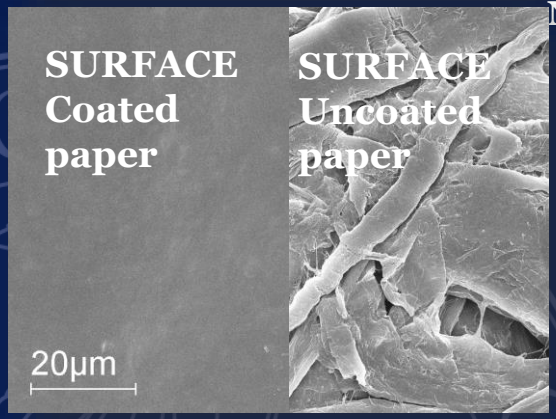


PACKLAB research: focus on functional barrier

BIO-BASED FILMS MADE by:

1. Maize <u>waxy</u> starch
2. Maize <u>normal</u> starch
3. Cationic starch mixture with <u>high amylose</u> content





Microstructural Observation

✓ **Thickness increase** (range: 11-16 µm);

✓ **Homogeneous and smooth layer** at the surface, able to fill the porous between cellulosic fibers

✓ Simple **bi-layer structure**.

Surface Properties

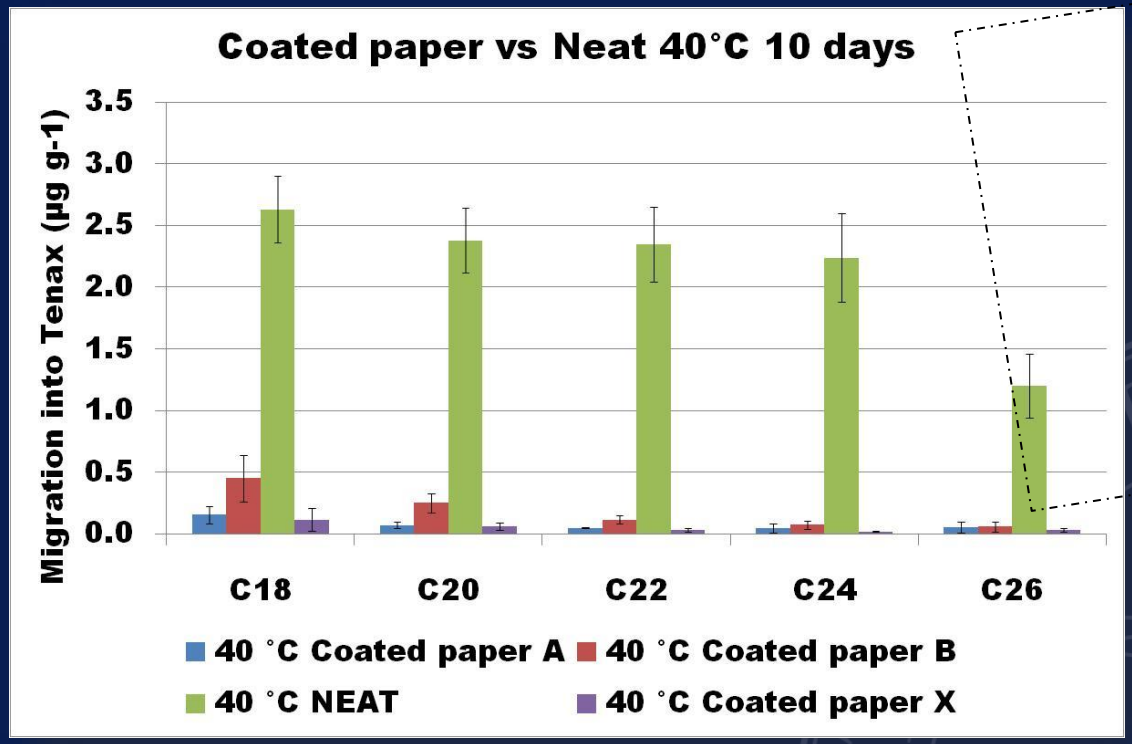
✓ All the bio-coated surfaces exhibited a medium hydrophobicity, without significant differences.

Contact angle measurements

	Gelatin	Gluten	Waxy starch	Starch
water (θ, °)	71.2^{c} ± 4.0	72.0^{c} ± 2.4	73.8^{c} ± 4.2	72.7^{c} ± 7.8

Guazzotti V, Marti A, Piergiovanni L, Limbo S. Bio-based coatings as potential barriers to chemical contaminants from recycled paper and board for food packaging. *Food Additives & Contaminants: Part A* ***2014; 31(3), pp. 402-413.***

PACKLAB research: focus on functional barrier



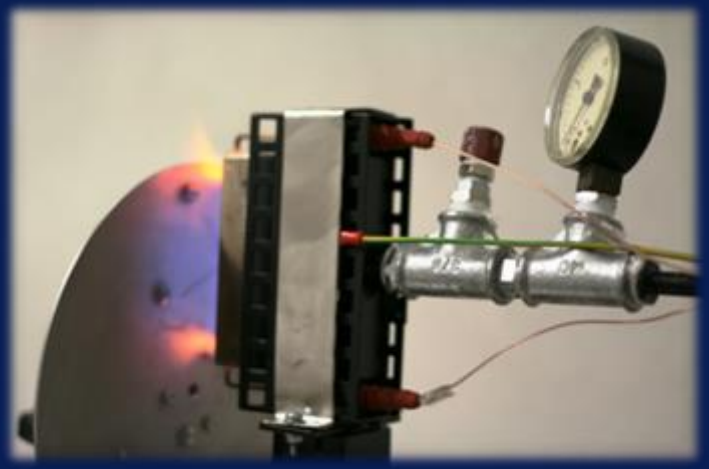
Uncoated VS Starch coated Paperboard: MIGRATION of ALKANES

Code	Description
A	Waxy starch
B	Normal starch
X	High amylose starch
NEAT	Uncoated

The average migration from starch coated paper for alkanes from C18 to C26 was significantly lower (ANOVA – 95% confidence level) compared with uncoated paper

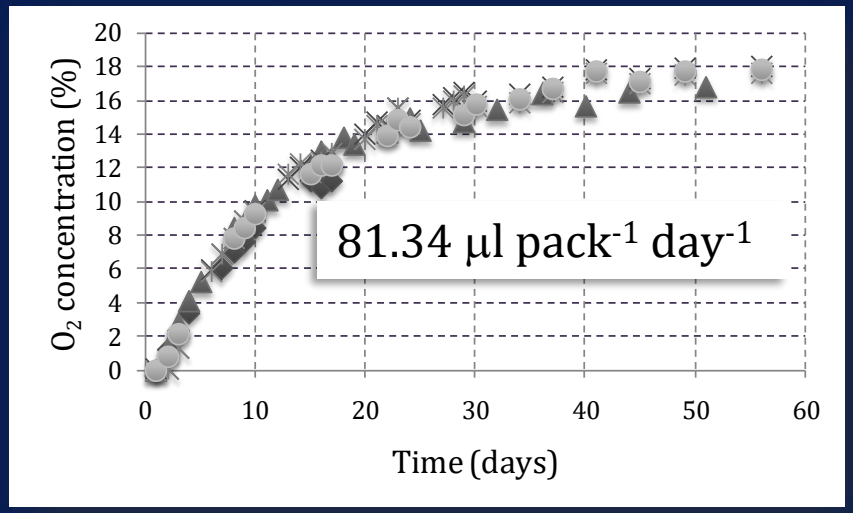
Guazzotti, V., Limbo, S., Piergiovanni, L., Fengler, R., Fiedler, D., Gruber, L. 2015. A study into the potential barrier properties against mineral oils of starch-based coatings on paperboard for food packaging. Food Packaging and Shelf Life Journal.

PACKLAB research: focus on surface treatments

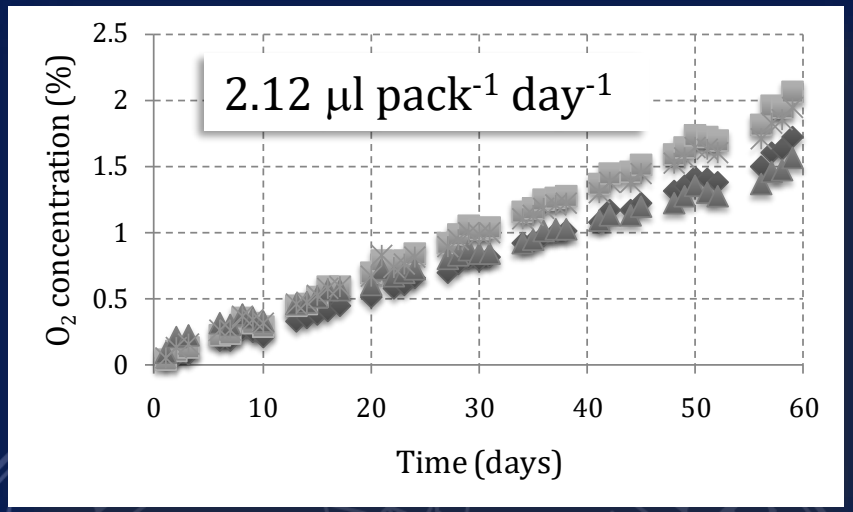


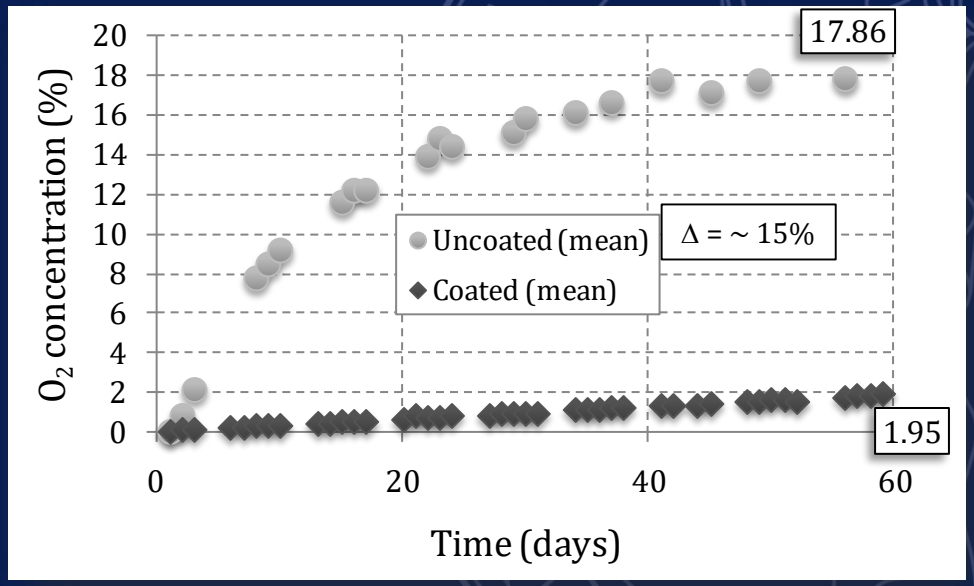
PACKLAB research: focus on surface treatments

Uncoated capsules*



Coated capsules*





*** T = 40°C RH = 25%**

Nominal inner atmosphere: 100% N_2

Critical issues, perspectives and Conclusions

Coatings can be a valuable place to include or to hide something really useful for the packaged food

One of the most intriguing perspectives is related to the possible thickness reduction of oil-based conventional plastic films, coating on them a thin layer of functional material, possibly bio-based.

The strategy of combining conventional plastic films with novel and performing coatings might be successful in achieving significant results in terms of packaging sustainability, not only from an environmental view but also in economic terms.

Since the major and most advanced researches in this field are addressed to shelf life extension, therefore the coating technology can be part of efforts aimed to reduce the huge problem of food waste and losses.