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Albstadt-Sigmaringen University



Film concept from potato-peel residues
AI-generated illustration

Plastic-Free Films for Life Sciences

Enabling a Circular Bioeconomy

Prof. Dr. Markus Schmid

Co-authors:

Mara Strenger, M.Sc.; Max Sturm, M.Sc., Matthias Bucher, M.Sc.
Manuel Hogg, Alina Kleiner, M.Sc., Luca Kirchmann

Institute Director, Sustainable Packaging Institute (SPI)
Albstadt-Sigmaringen University

Future of BioPackaging 2026, online
1 October 2026

The Sustainable Packaging Institute (SPI)



Packaging research (concept)
AI-generated illustration

Research and teaching in six fields

1. Biogenic resources
2. Process engineering and process design
3. Functional materials
4. Smart packaging (active and intelligent)
5. Preservation and packaging
6. Bioeconomy and sustainability

Research focus: Sustainable packaging concepts

Plastic-free: definition and examples

EU definition: natural polymers that have not been chemically modified are excluded from “plastic”.

Can qualify as plastic-free	Remain plastics
Native starch, cellulose or whey protein Polymer formed in nature Chemical structure remains unchanged	Bio-PE, PLA, PHA or cellulose acetate Bio-based or biodegradable origin alone does not qualify

Paper + qualifying protein coating: potentially plastic-free.

The same coating on PE film: the complete pack still contains plastic.

The assessment includes all layers, sealants, adhesives and additives.

SUPD Art. 3(1), PPWR Art. 3(1)(52), updated Commission guidelines C/2026/4813

Waste biomass as a functional materials source

Side stream / fraction	Useful function	Design limitation
Whey / proteins	Oxygen and grease barrier	Humidity sensitivity
Potato residues / starch Fruit pomace / pectin	Film-forming matrix Coatings on paper	Water sensitivity Batch variability
Recovered waxes / lipids	Moisture resistance	Cracking and sealing

**Complementary layers combine functions.
Humidity and defects control performance.**

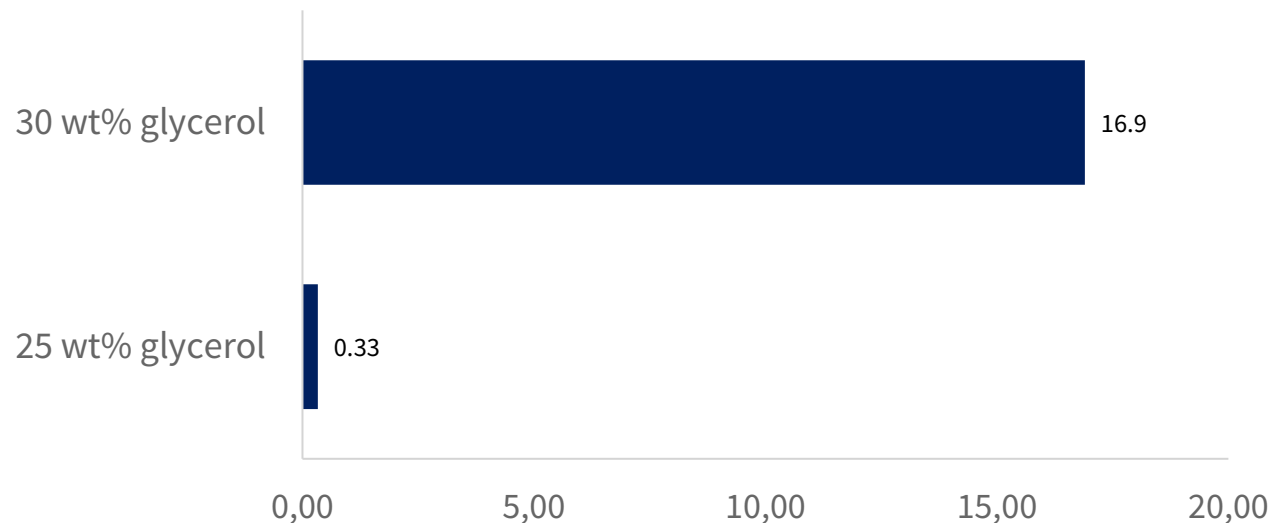
Material functions: Chen et al. (2019), Cazón et al. (2017) and Devi et al. (2024).



Food-processing side streams
KI-generiert / AI-generated

New evidence: microbial protein films

Oxygen permeability at 23 °C and 50% RH



$\text{cm}^3 \text{ mm m}^{-2} \text{ day}^{-1} \text{ atm}^{-1}$ (lower is better for oxygen sensitive food)

Baddigam et al. (2025). Means: 25% glycerol n=5, SD=0.7 (3 below detection), 30% glycerol n=3, SD=4.2.

Strong barrier potential

The formulation strongly changes oxygen transport.

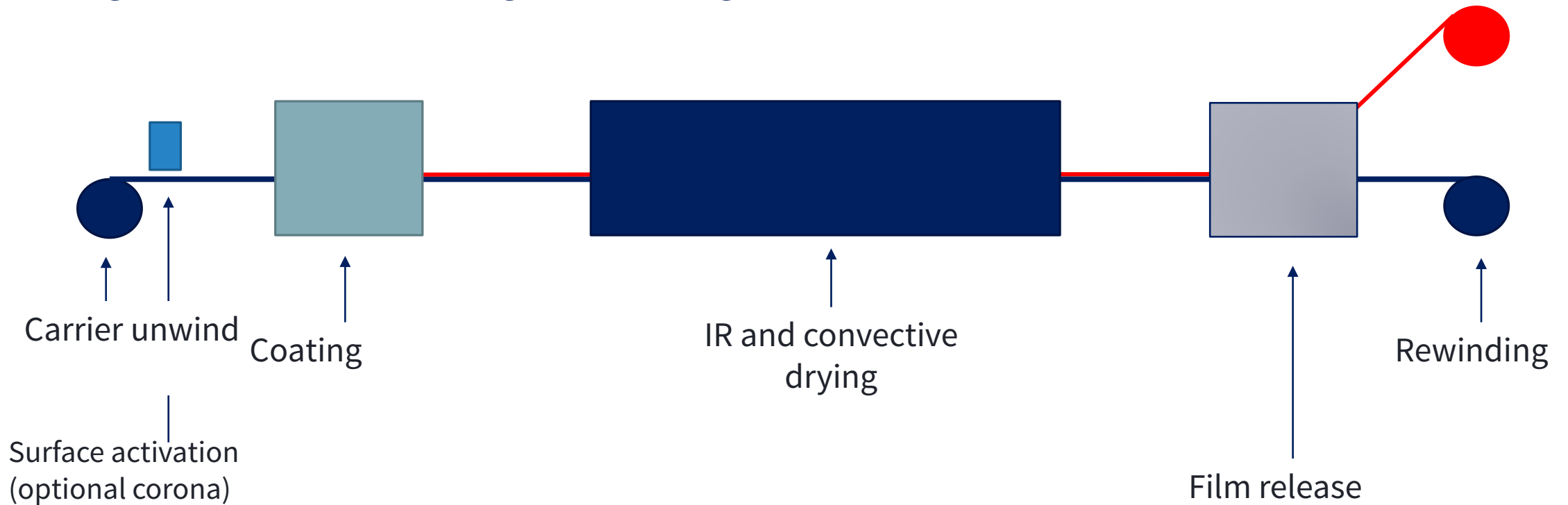
Laboratory evidence leaves humidity robustness and industrial conversion open.

Performance benchmark.
Plastic-free status needs a separate assessment.

Continuous roll-to-roll processing



Drying load at 10% solids: 9 kg water per kg dry material



At 20% solids: 4 kg water. Higher solids require workable viscosity.

Current SPI development priorities

BIOSEALING

November 2025 – October 2027

Natural-polymer films for extrusion

Oxygen barrier and sealability

Demonstrators and life-cycle assessment

[BIOSEALING project details](#)

Research objectives. Commercial readiness requires validation in the intended pack.

Sources: SPI project descriptions for BIOSEALING and BioGelPack, accessed 22 September 2026.

BioGelPack

Coatings for food and non-food packs

Animal protein and plant-based alternatives

Plastic-free coating concepts

Recyclability as a development objective

[BioGelPack project details](#)



Application fit across life sciences

Candidate application	Main opportunity	Evidence needed
Grease-resistant food paper	Thin natural-polymer coating	Grease resistance, migration and repulpability
Dry food / nutraceutical packs	Oxygen-barrier films or layers	Humidity robustness, sealing and shelf life
Cosmetic / pharmaceutical packs	Selected coatings and secondary packaging	Compatibility and stability for the specific use

Sterile, wet-product and long-shelf-life primary packs require substantially more validation.

Food-contact safety framework: Regulation (EC) 1935/2004.



Illustrative packaging concepts
KI-generiert / AI-generated

Circularity and sustainability: practical examples

Examples for assessing the complete packaging system

Example	What determines the environmental outcome
Protein-coated paper tray	Paper recycling needs fibre recovery. Coating residues must not disrupt the process.
Oxygen-sensitive nuts	A thinner film may let oxygen in and cause rancidity. Compare packs with the same product shelf life.
Film from potato side streams	Residues can avoid demand for new crops. Extraction and drying still need energy.

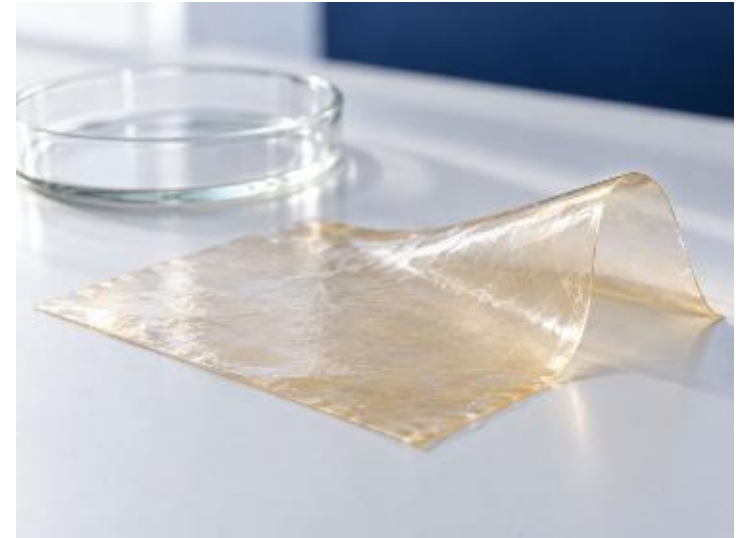
2026 LCA: climate benefits can coincide with higher land-use impacts on biodiversity.

Illustrative cases. Paper recycling: Cepi (2025). Broader bio-based plastics LCA: Erradhouani et al. (2026).

Plastic-free films in a circular bioeconomy

**Natural polymers offer useful barrier functions.
Industrial value depends on the complete pack.**

An application-specific demonstrator needs
validated protection, scalable processing
and a credible recovery route.



Film concept, KI-generiert / AI-generated

“A circular bioeconomy, guided by circular design, can be a key pathway towards a restorative and regenerative economy.”

Prof. Dr. Markus Schmid schmid@hs-albsig.de www.hs-albsig.de/spi

Let's stay in touch

Prof. Dr. Markus Schmid



Research & Teaching

Director, SPI

Sustainable Packaging Institute

Research collaborations

Sustainable packaging concepts

schmid@hs-albsig.de

[+49 7571 732-8402](tel:+4975717328402)

www.hs-albsig.de/spi



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Shaping a sustainable future together

Scientific references

Baddigam, K. R., et al. (2025). Communications Chemistry 8, 297.

High oxygen barrier packaging materials from protein-rich single-celled organisms.

<https://doi.org/10.1038/s42004-025-01720-x>

Chen, H., et al. (2019). Polymers 11(12), 2039.

Application of Protein-Based Films and Coatings for Food Packaging: A Review.

<https://doi.org/10.3390/polym11122039>

Cazón, P., et al. (2017). Food Hydrocolloids 68, 136–148.

Polysaccharide-based films and coatings for food packaging: A review.

<https://doi.org/10.1016/j.foodhyd.2016.09.009>

Devi, L. S., Jaiswal, A. K., & Jaiswal, S. (2024). Current Research in Food Science 8, 100720.

Lipid incorporated biopolymer based edible films and coatings in food packaging: A review.

<https://doi.org/10.1016/j.crfs.2024.100720>

Erradhouani, B., Coma, V., Sonnemann, G., & Loubet, P. (2026). Nature Communications 17, 3630.

Transition to bio-based plastic packaging reveals complex climate–biodiversity trade-offs.

<https://doi.org/10.1038/s41467-026-69016-9>

The cited studies support the specific statements on slides 4, 5 and 9. They do not validate SPI products.

Regulatory references

EU plastic definition

Directive (EU) 2019/904, Article 3(1). Natural polymers that have not been chemically modified.

<https://eur-lex.europa.eu/eli/dir/2019/904/oj>

Commission guidance on single-use plastics

Commission Notice C/2026/4813, 8 September 2026, section 2.1.3. Interpretative guidance.

<https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52026XC04813>

Packaging and Packaging Waste Regulation (PPWR)

Regulation (EU) 2025/40, Articles 3(1)(52), 5(5), 6, 9 and 71. General application: 12 August 2026.

<https://eur-lex.europa.eu/eli/reg/2025/40/oj>

Food-contact safety

Regulation (EC) 1935/2004, Article 3. General safety requirements for food-contact materials.

<https://eur-lex.europa.eu/eli/reg/2004/1935/oj>

PPWR PFAS limits for food-contact packaging apply from 12 August 2026. Recyclability obligations have later deadlines.

Methods and project information

Paper recyclability: Cepi laboratory test method

Version 3, February 2025. Pulping, screening and sheet formation.

<https://www.cepi.org/cepi-recyclability-test-method-version-3/>

BIOSEALING

SPI project description. Project period: November 2025 to October 2027.

<https://www.hs-albsig.de/forschungsdetailseite/biosealing/>

BioGelPack

SPI project description. Animal and plant proteins. Project period: December 2025 to November 2028.

<https://www.hs-albsig.de/forschungsdetailseite/biogelpack/>

BioShieldProcess: continuous film manufacture

Albstadt-Sigmaringen University, project announcement of 9 October 2024.

<https://www.hs-albsig.de/detail/hochschule-erhaelt-knapp-zwei-millionen-euro-fuer-grossgeraet/>

European Commission: PPWR application update, 11 August 2026

References and links checked: 22 September 2026. Project objectives are research targets, not product approvals.

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Slide 5: chart redrawn from reported data in Baddigam et al. (2025). The article is licensed CC BY 4.0. Chart design adapted.

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