Hochschule Albstadt-Sigmaringen
Albstadt-Sigmaringen University

Whey protein-based oxygen barrier coatings and modifications at lab and pilot scale

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Bio-based coatings and food contact materials

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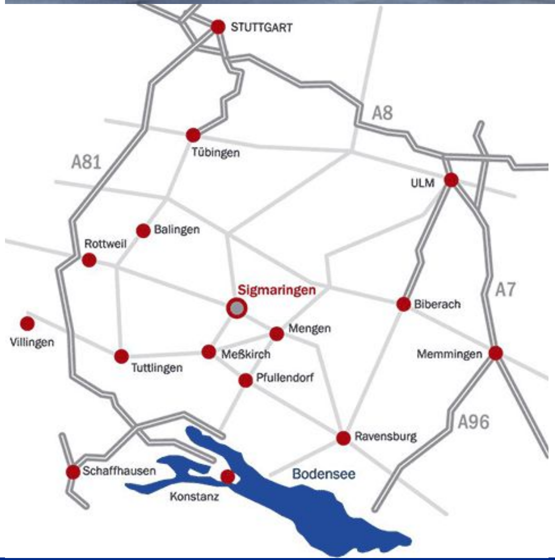


- The Sustainable Packaging Institute, SPI for short, is involved in research & teaching in six thematic areas
- The Institute has a research focus on "**Sustainable packaging concepts**"

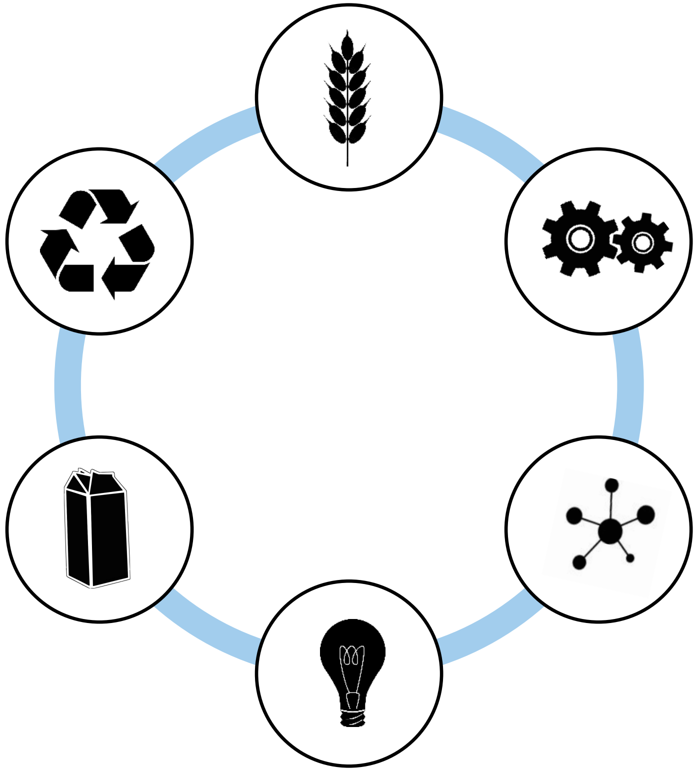

„We strive for a more sustainable circular bioeconomy.“

Mission Statement

"To support all players in the packaging industry along the entire value chain in the life science industry on their way to a more sustainable, circular bioeconomy, competently and holistically."

Thematic areas of the SPI

1. Biogenic raw materials



2. Process technology & Process design

3. Functional materials

4. Smart packaging (Active & intelligent Packaging)

5. Preservation & Packaging

6. Bioeconomy & Sustainability (Concepts, Assessment & Perception)

Current projects at the SPI

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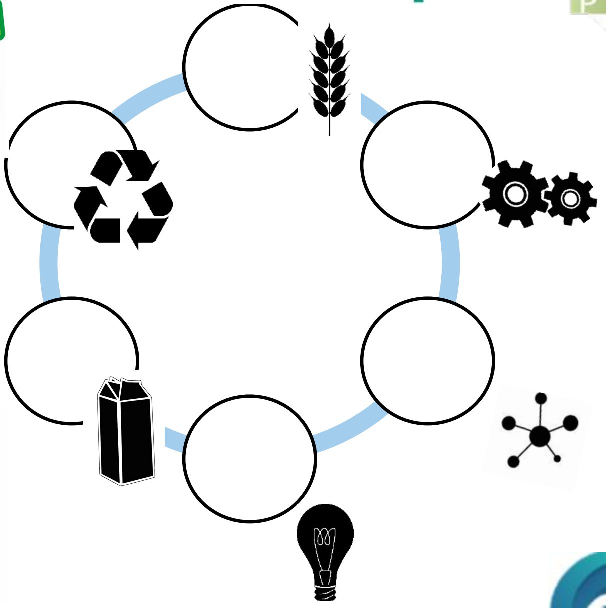

ZIM
Zentrales Innovationsprogramm Mittelstand

ZIM - HOT Screen
ZIM - Heyne & Penke
ZIM - Hugo Beck

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ViPack

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Project presentations and project updates can be found at:
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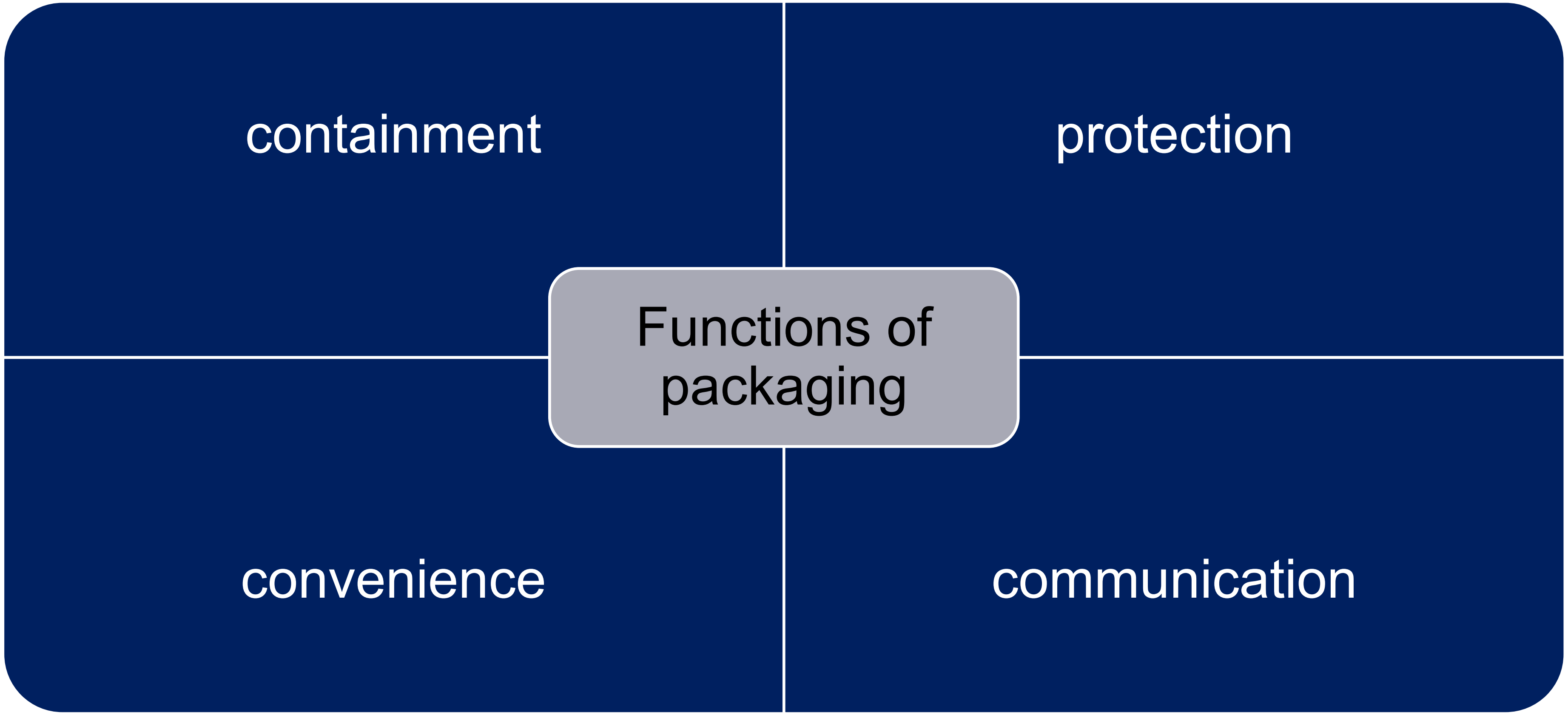
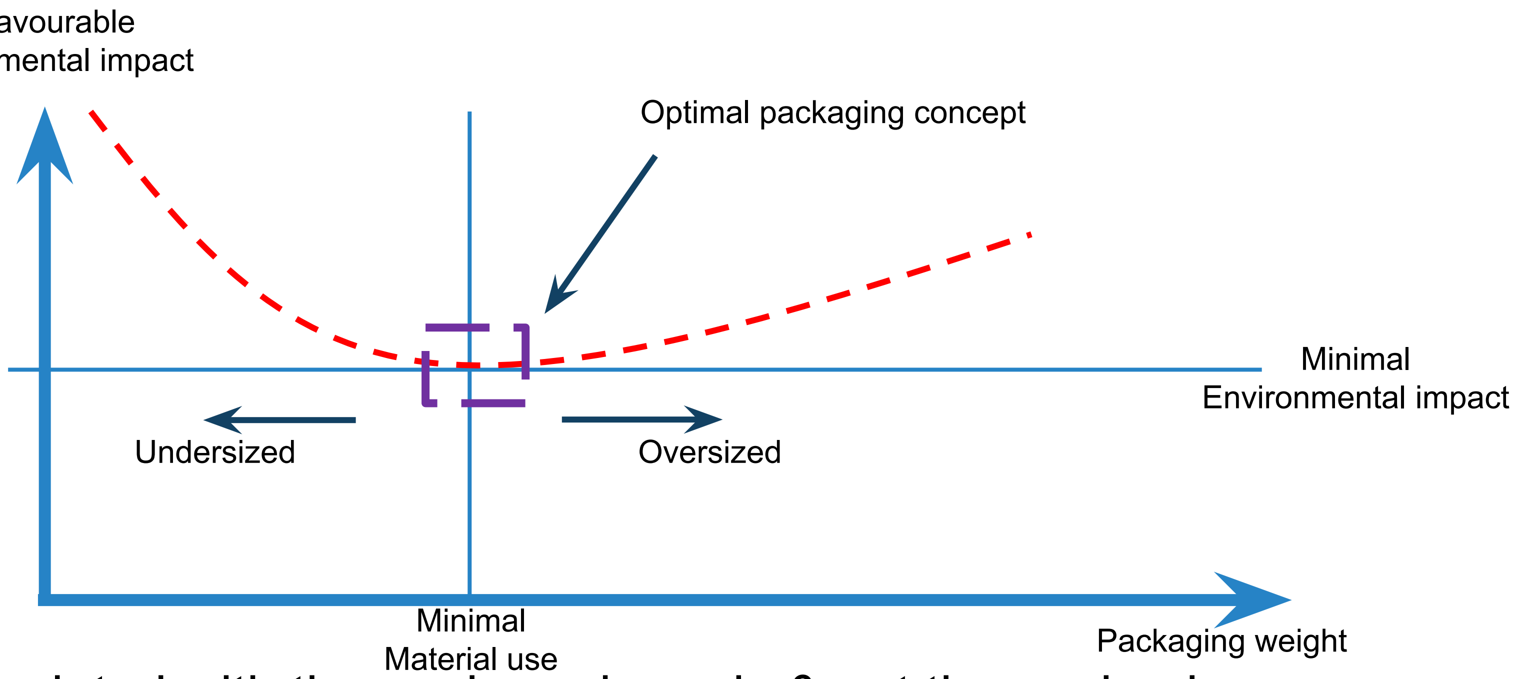
Functions of packaging



Sustainability aspects in packaging concepts

Sustainability aspects to consider when quantifying potential environmental impacts of packaging concepts:

- Environmental impact of the dimensioning
- Advanced sustainability aspects of food waste, especially with Undersizing



→ The majority of resources are associated with the packaged goods & not the packaging material,
BUT no legitimisation for not transferring packaging as a resource into the highest possible added value.

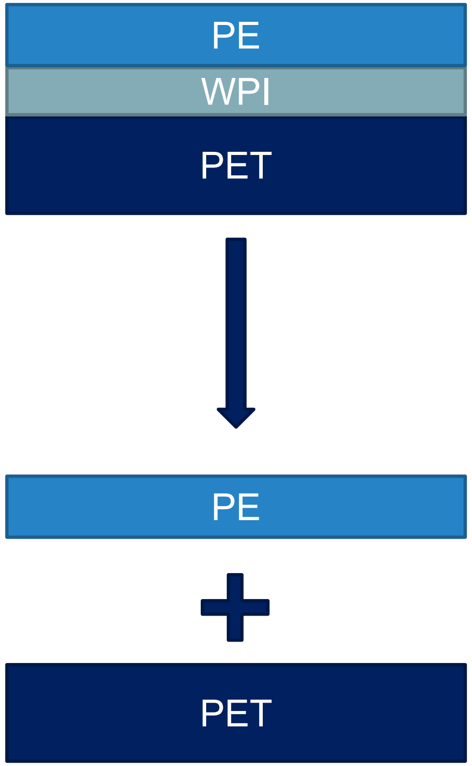
Fig.: optimal packaging concept based on [1]

Introduction on whey proteins

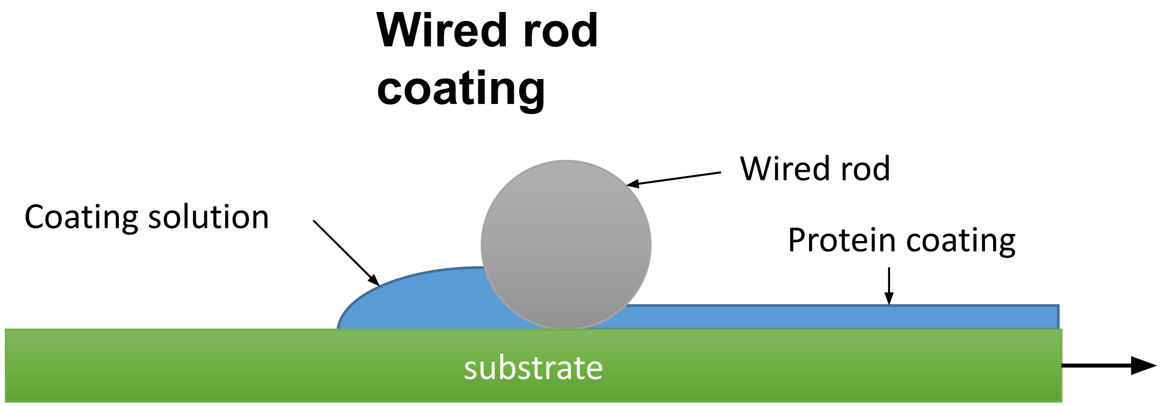
- Whey by-product of cheese manufacturing
- Use as food supplements, animal feed, fertilizer or discarded[6]
- Yearly production in Europe: 50 mio. t, large portion of which is discarded

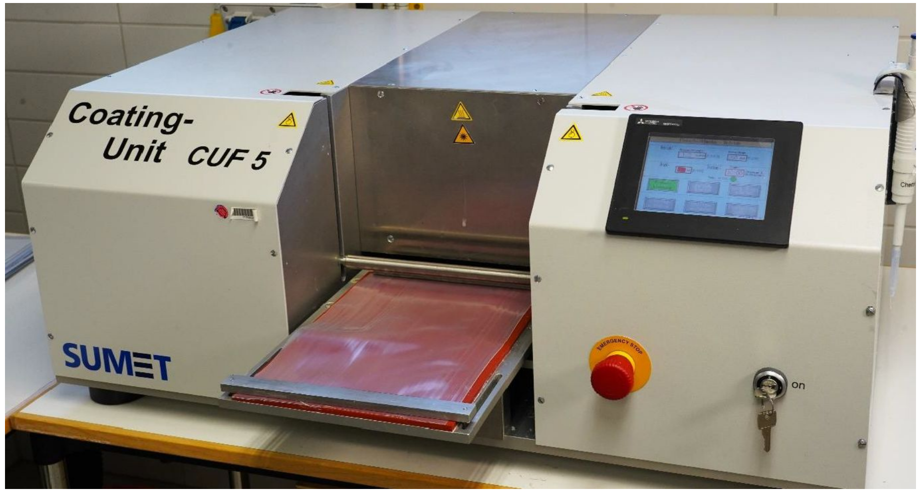
   non-food competitive source

- Potential bio-based alternative to EVOH due to high oxygen barrier properties[7]
- Use of protein layer to allow separation of multilayer structures in recycling



Coating application at lab scale

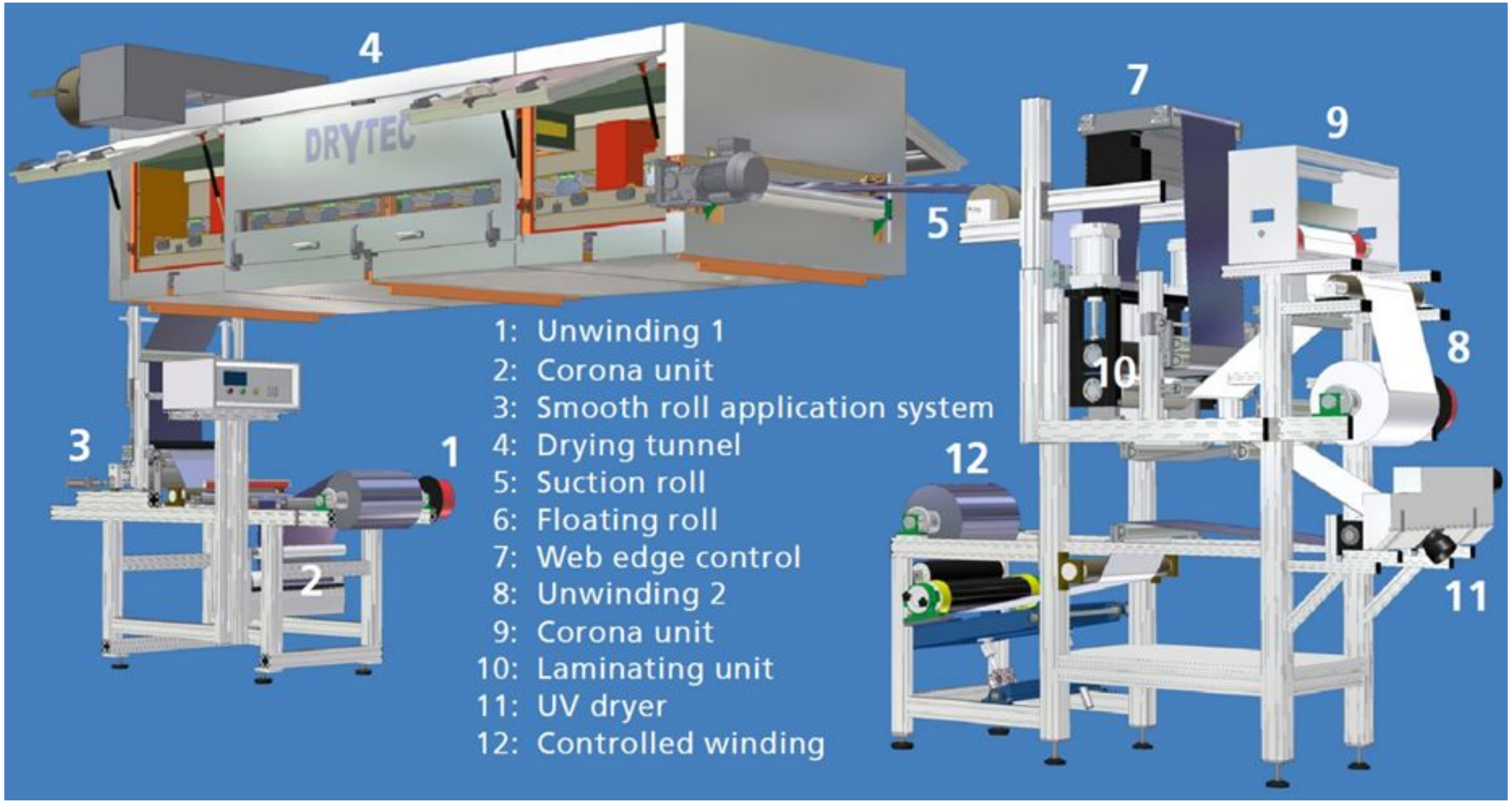




Lab scale coating: Coating unit CUF5

Highly transparent whey protein coated PLA film

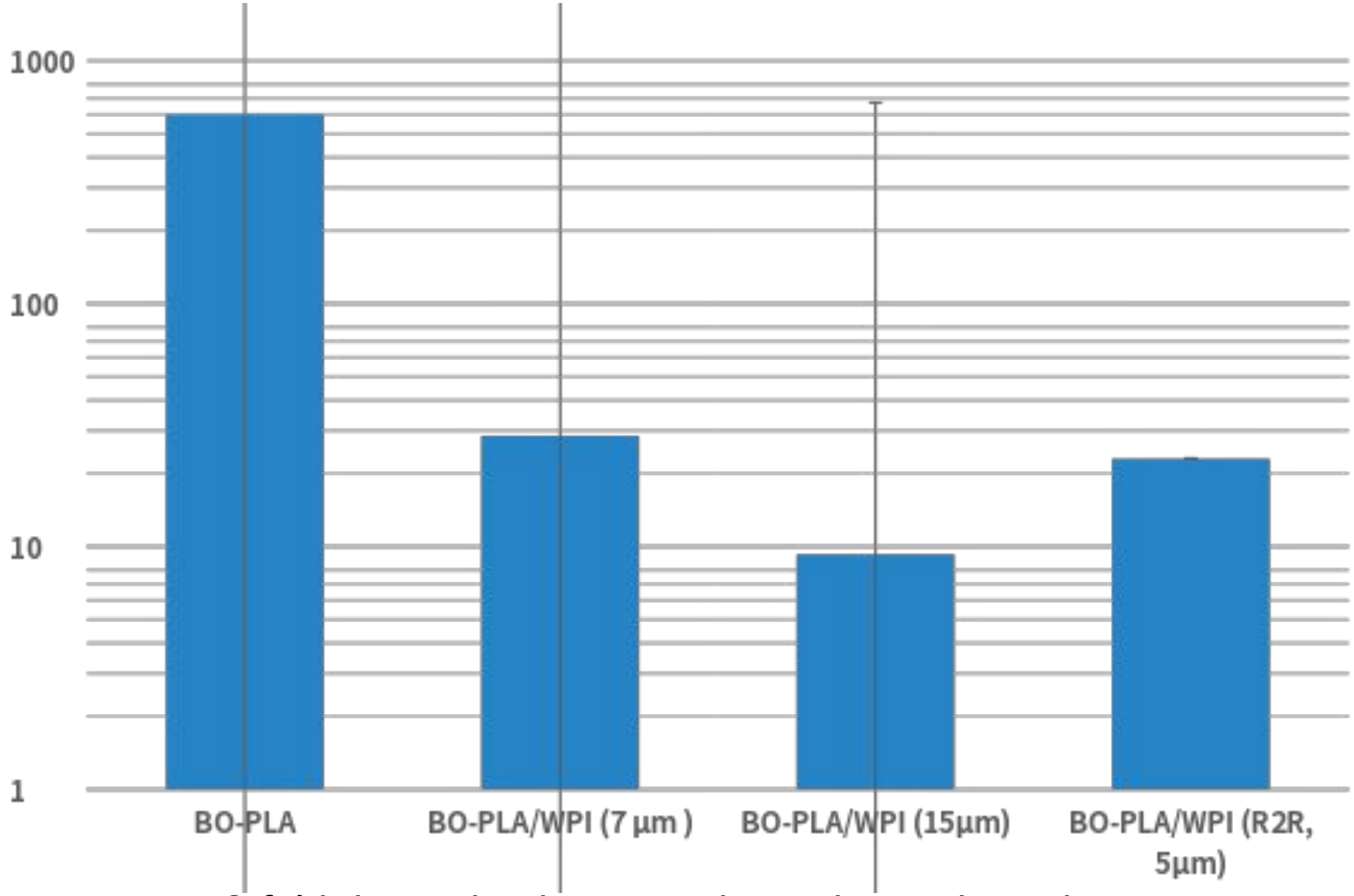
Coating application at pilot scale



Whey protein coating on PLA substrate

Oxygen transmission rate:

- reduction by factor 21 for 1 coating layer (29 cm³/m²d bar) and 65 for 2 coating layers (9.3 cm³/m²d bar)
- Reduction by factor 26 at pilot scale with lower coating thickness

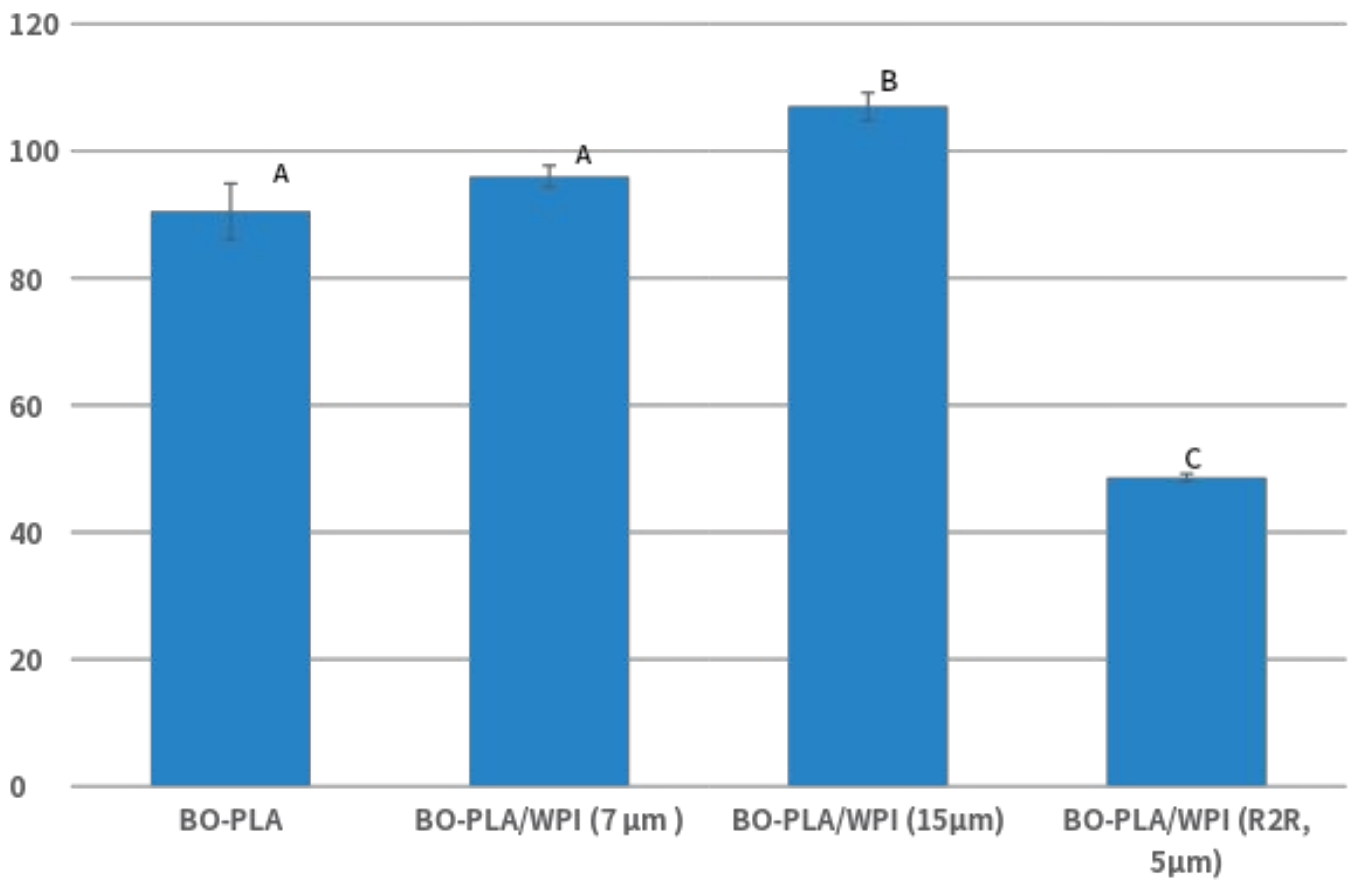


2-fold determination, error bars show min and max values

Whey protein coating on PLA substrate

Water vapour transmission rate:

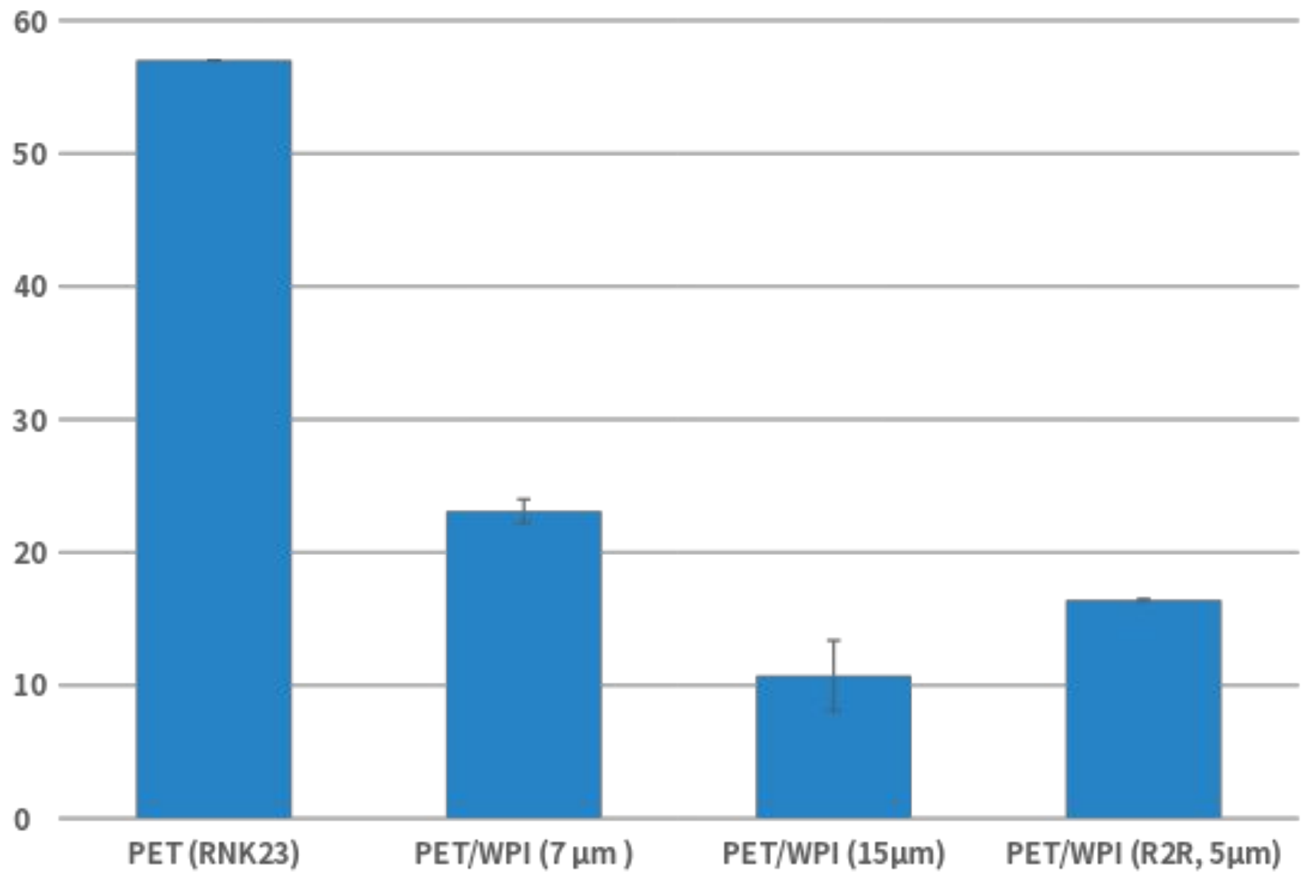
- Increasing with coating thickness of whey protein coating
- Similar WVTR of coated and non-coated films
- Due to hydrophilic nature of whey protein



Whey protein coating on PET substrate

Oxygen transmission rate:

- Reduction by factor 2.5 and 5.3 for 1 and 2 coating layers on PET, respectively
- Reduction by factor 3.5 at pilot scale with lower coating thickness

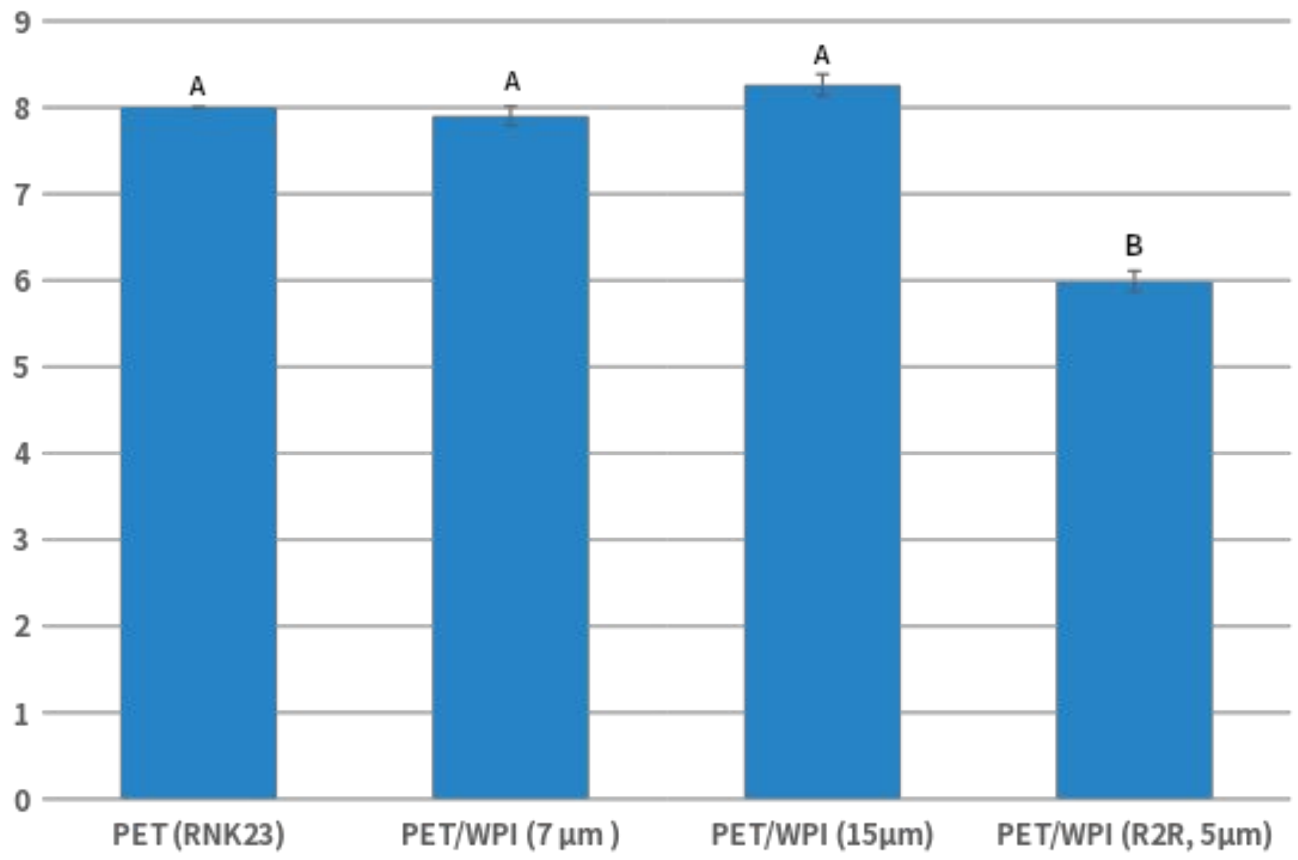


2-fold determination, error bars show min and max values

Whey protein coating on PET substrate

Water vapour transmission rate:

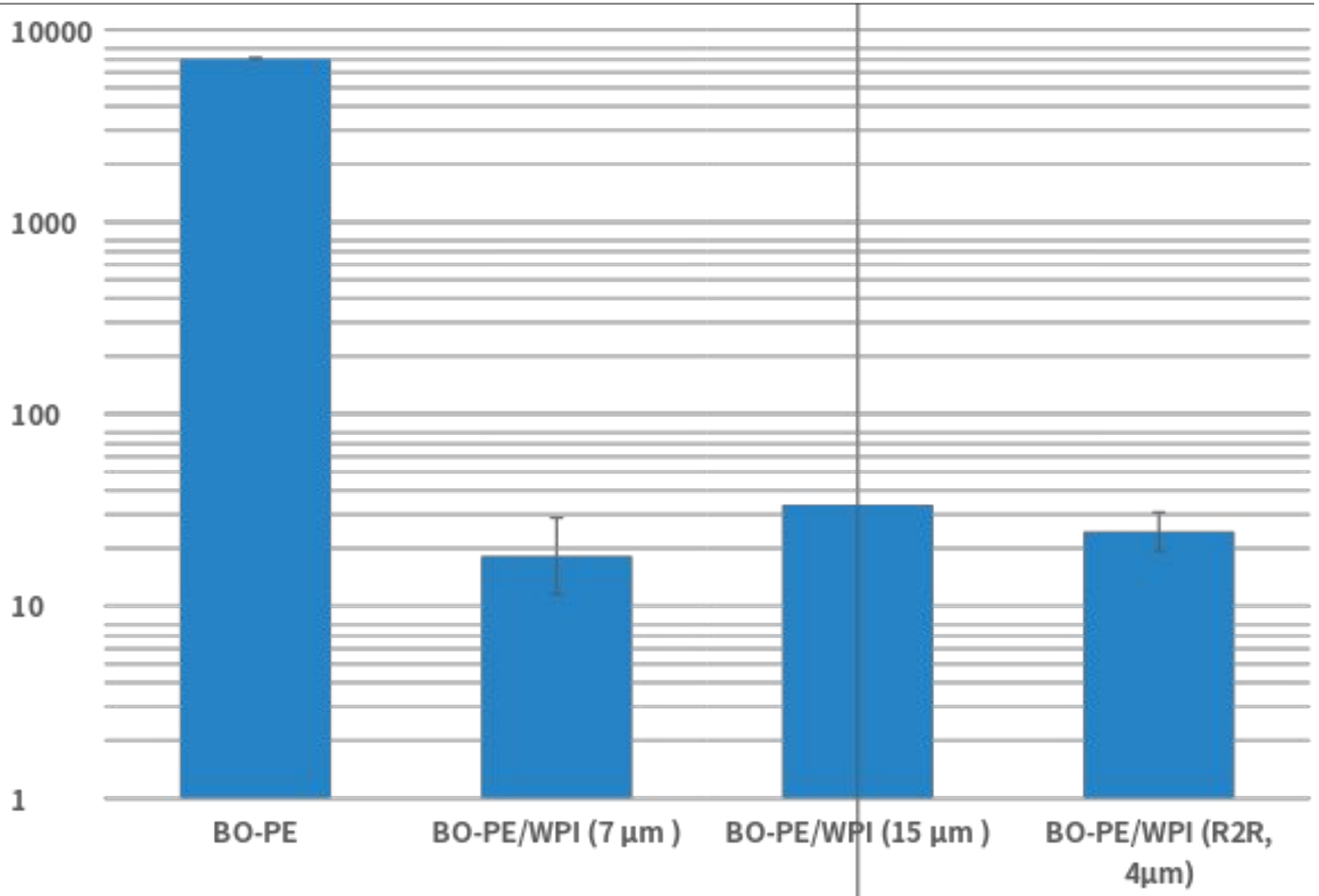
- Similar WVTR of coated and non-coated films



Whey protein coating on PE substrate

Oxygen transmission rate:

- Reduced by factor 390 for 1 whey protein coating layer and 211 for 2 coating layers, respectively
- Reduced by factor 290 at pilot scale with lower coating thickness

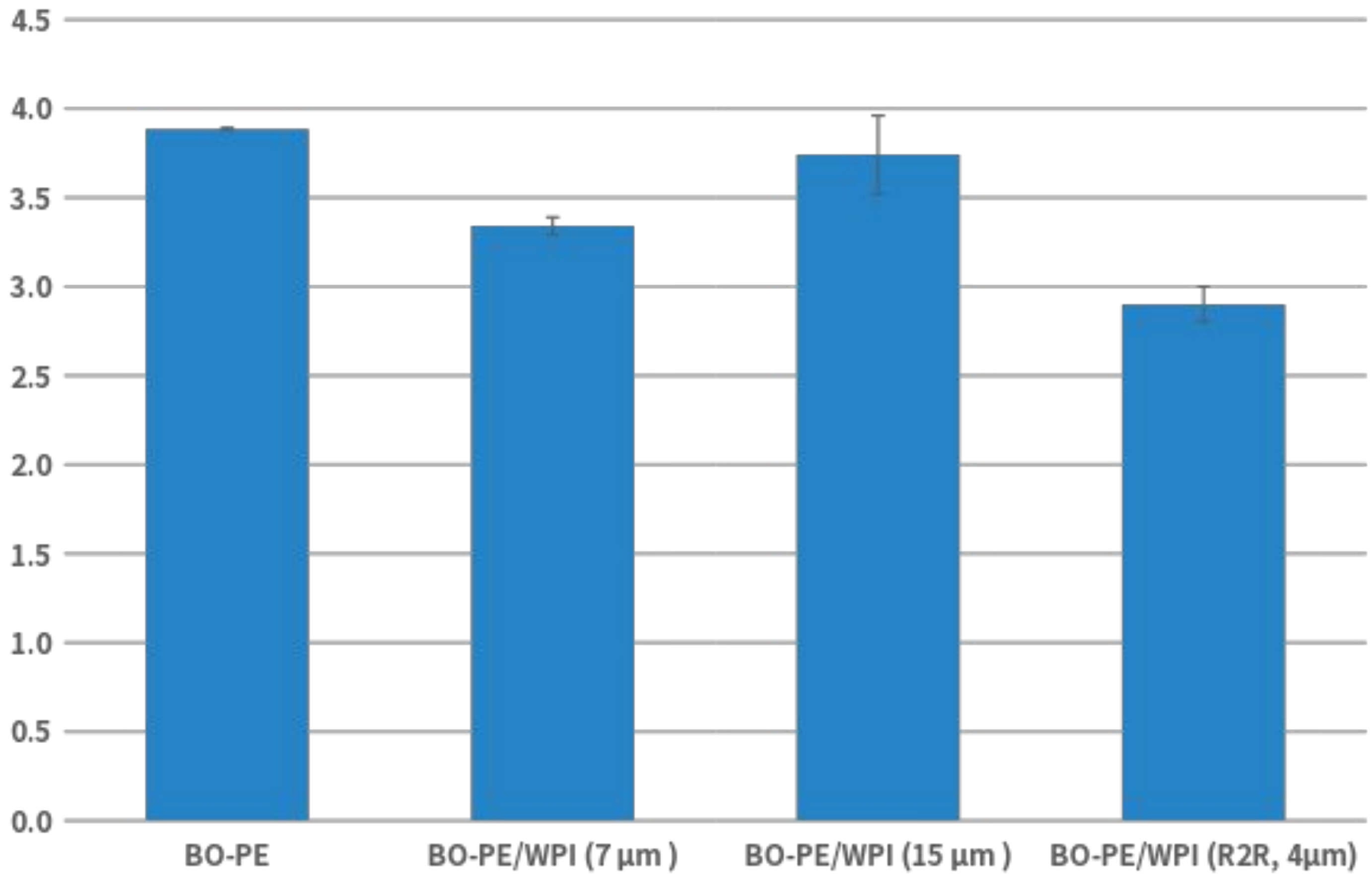


2-fold determination, error bars show min and max values

Whey protein coating on PE substrate

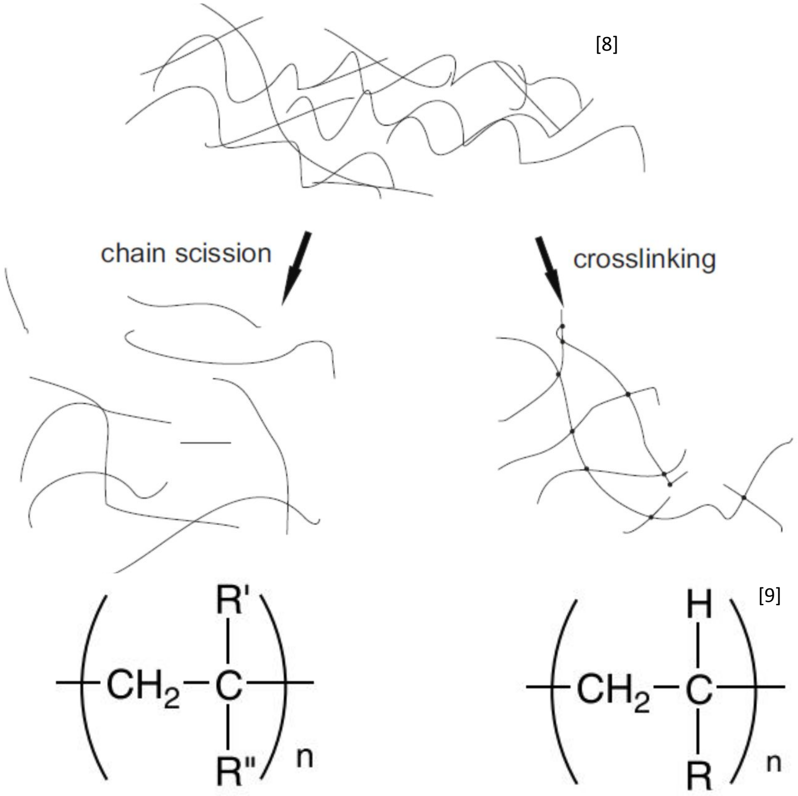
Water vapour transmission rate:

- Similar WVTR of coated and non-coated films



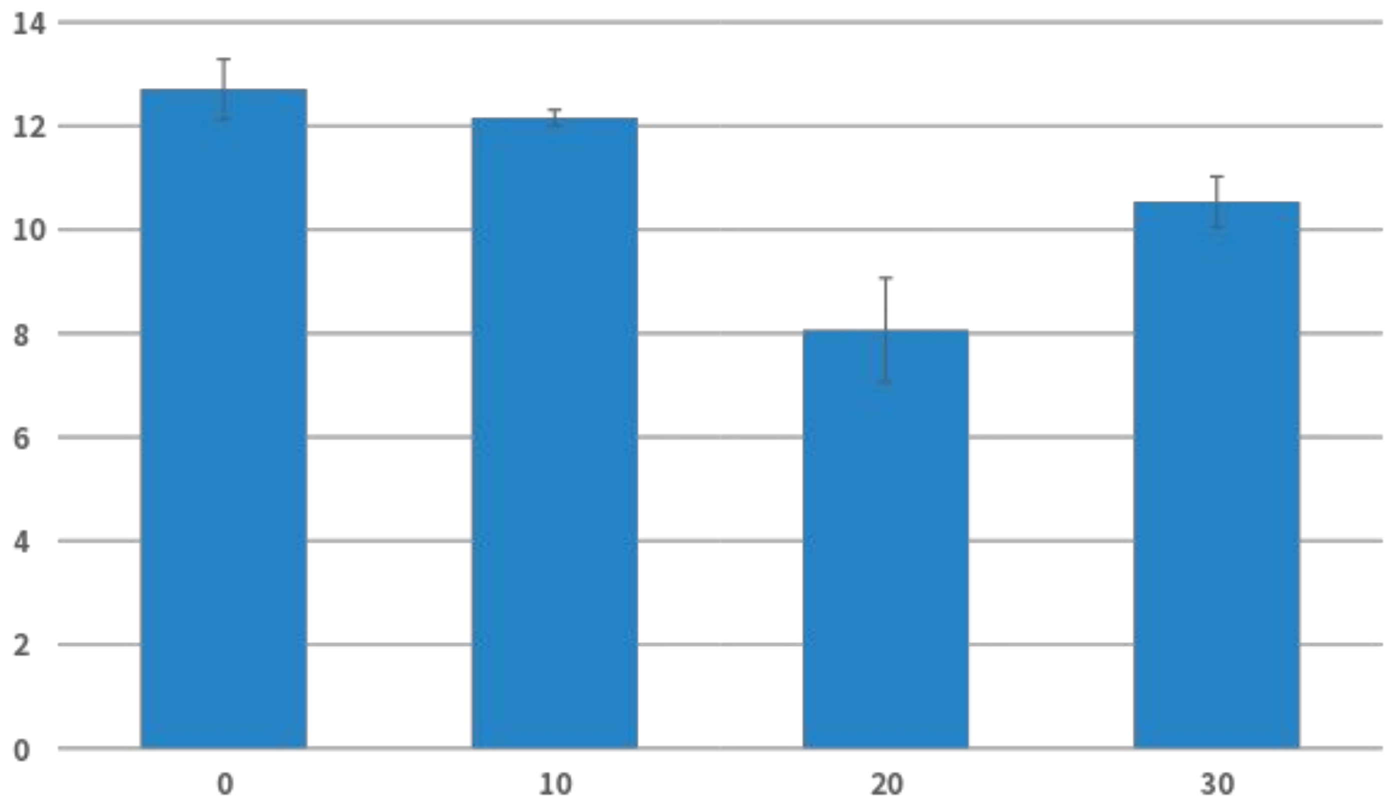
Fundamentals of eBeam irradiation

- Main processes caused by irradiation
  - Chain scission
  - Crosslinking
- Ratio depends on
  - Chemical structure of polymer
  - Irradiation atmosphere (air, nitrogen, etc.)
  - Irradiation dose



eBeam treatment of whey protein coated PET

Oxygen transmission rate:
- Reduced by factor 1.3 for 20 kGy dose
- Possible explanation: induction of cross-linking reaction of proteins forming denser molecular network
- further investigations required

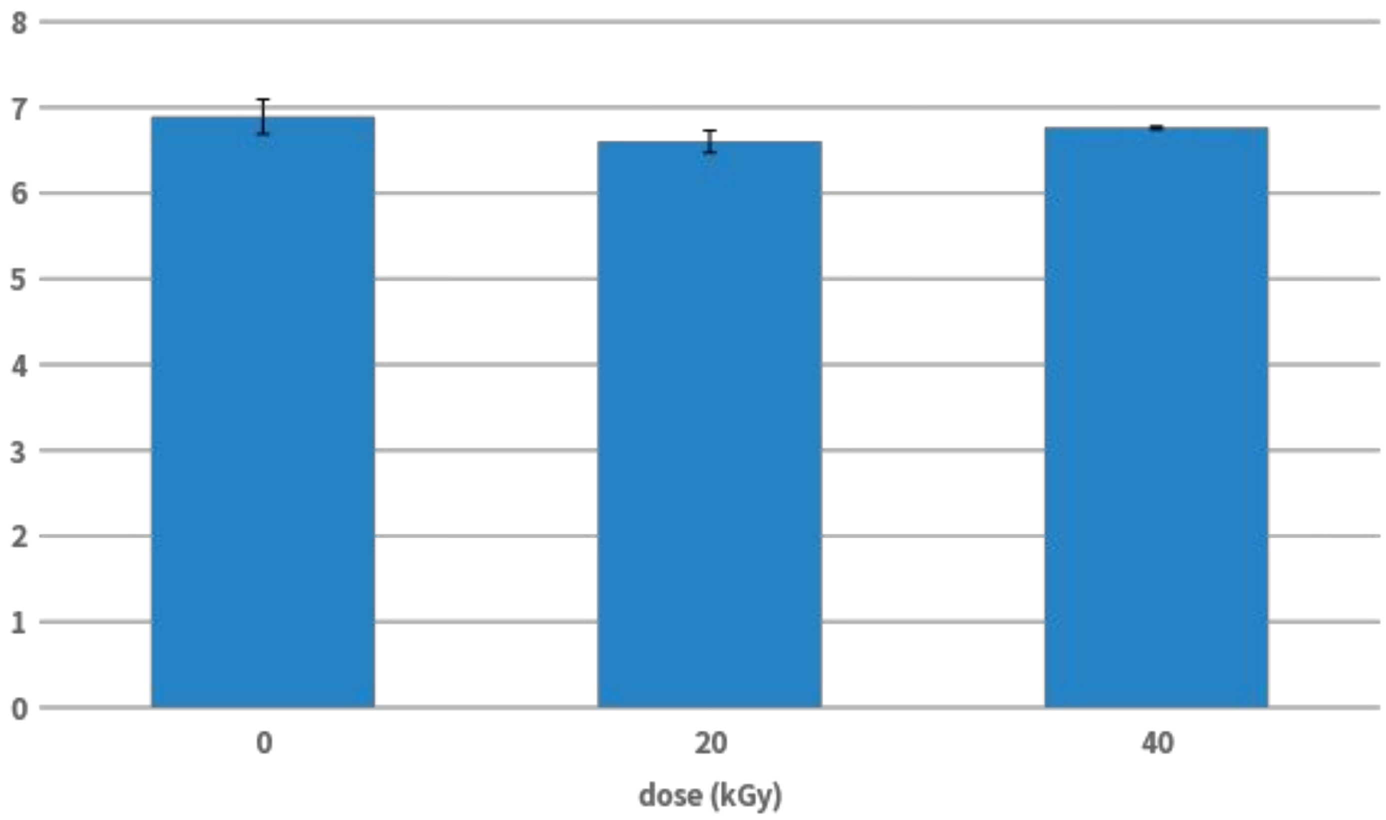


2-fold determination, error bars show min and max values

eBeam treatment of whey protein coated PET

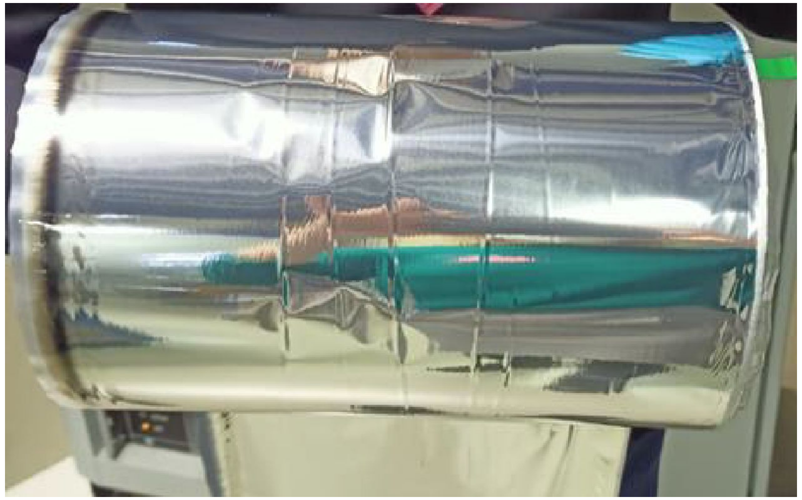
Water vapour transmission rate:

- Not effected by electron beam treatment
- Low WVTR of PET compared to WPI coating
- No effect expected

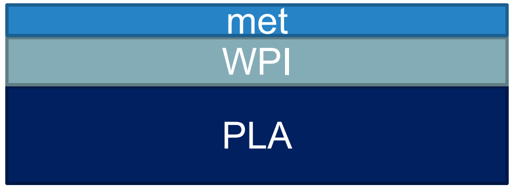


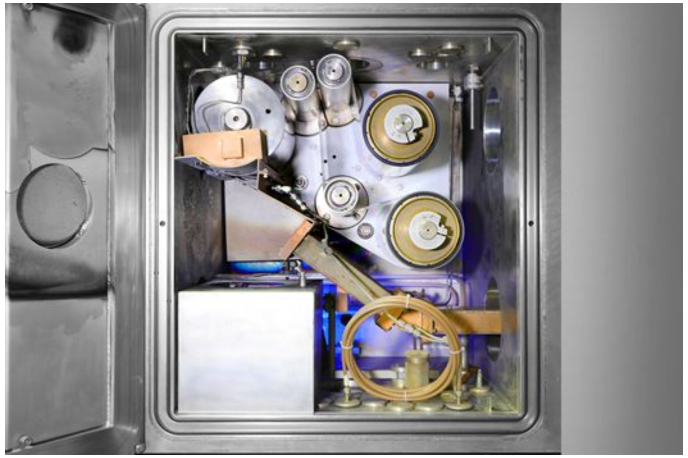
Metallization of whey protein coated films

- Metallization of whey protein coated films using a physical vapour deposition process in a high vacuum chamber and electron beam evaporator



Metallized and whey protein coated PET



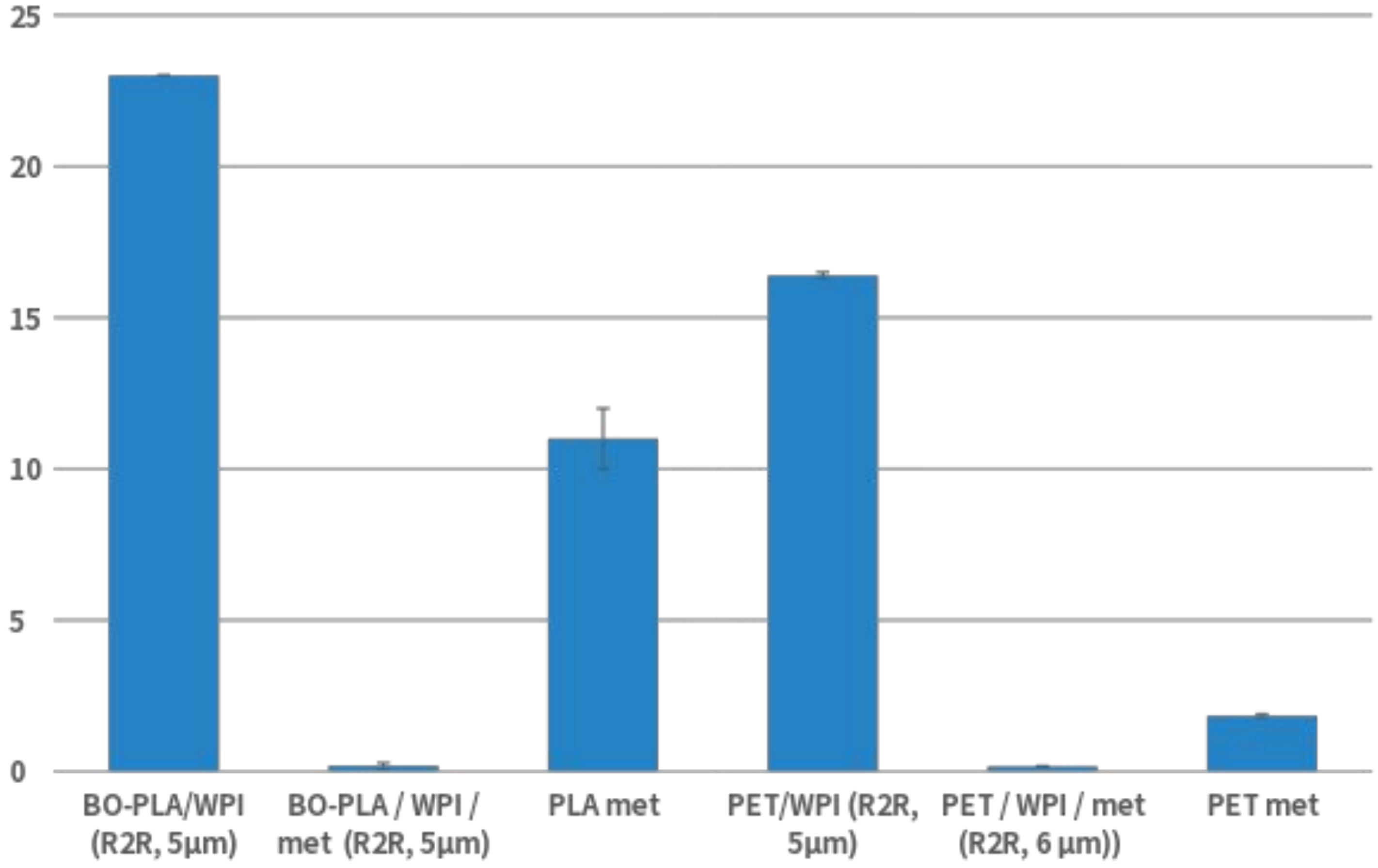


Physical vapour deposition vacuum chamber

Metallization of whey protein coated films

Oxygen transmission rate:

- < 0.2 cm³/(m² d bar) after metallization of protein coated PET and PLA films
- Similar or better oxygen barrier compared to metallized or protein coated films

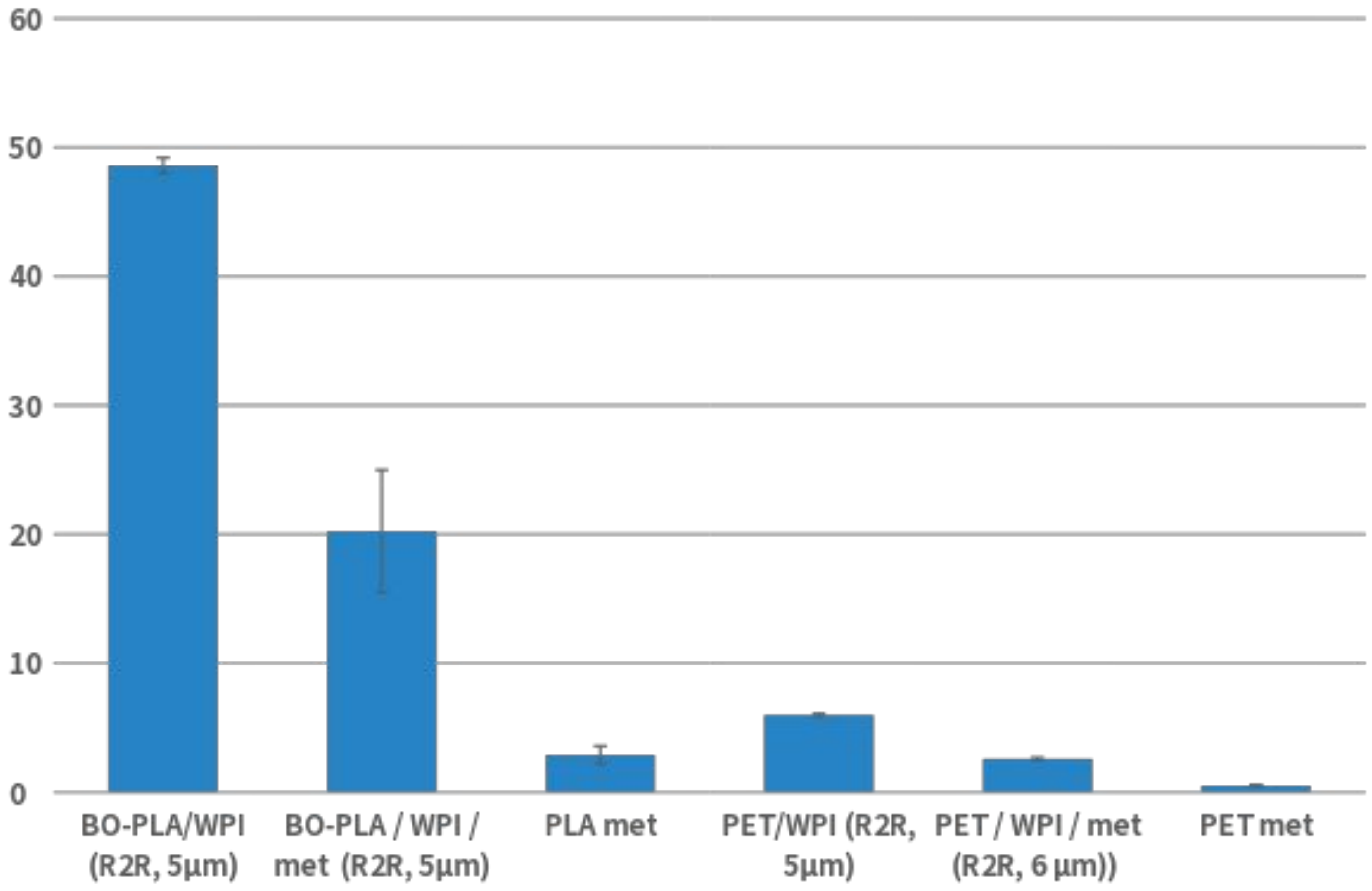


2-fold determination, error bars show min and max values

Metallization of whey protein coated films

Water vapour transmission rate:

- Reduction by factor 2.4 and 2.3 for metallized whey protein coated PLA and PET, respectively



Conclusion

- OTR decrease by whey protein coating for PLA, PE and PET films
- WVTR increased 18 % for PLA and 5 % for PET
- Electron beam irradiation further reduced OTR of coated PET
- Metallization further reduced OTR and WVTR of coated films

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Thank you for your attention!

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