# Study on functional coatings for food, cosmetic and pharmaceutical packaging on the basis of biodegradable ORMOCER®s

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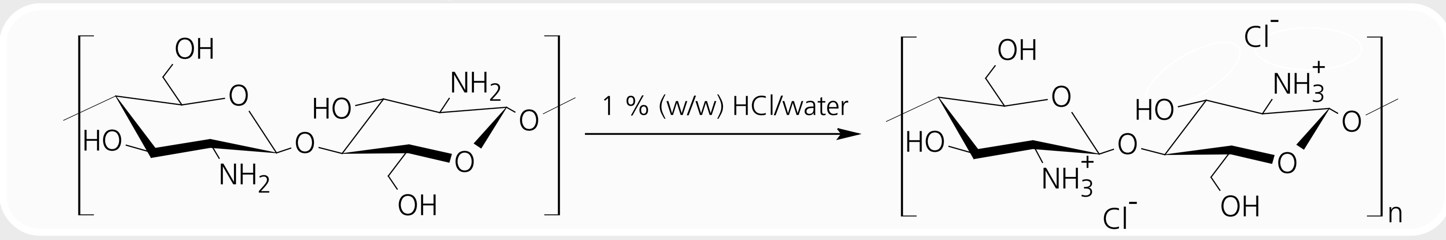
## Introduction

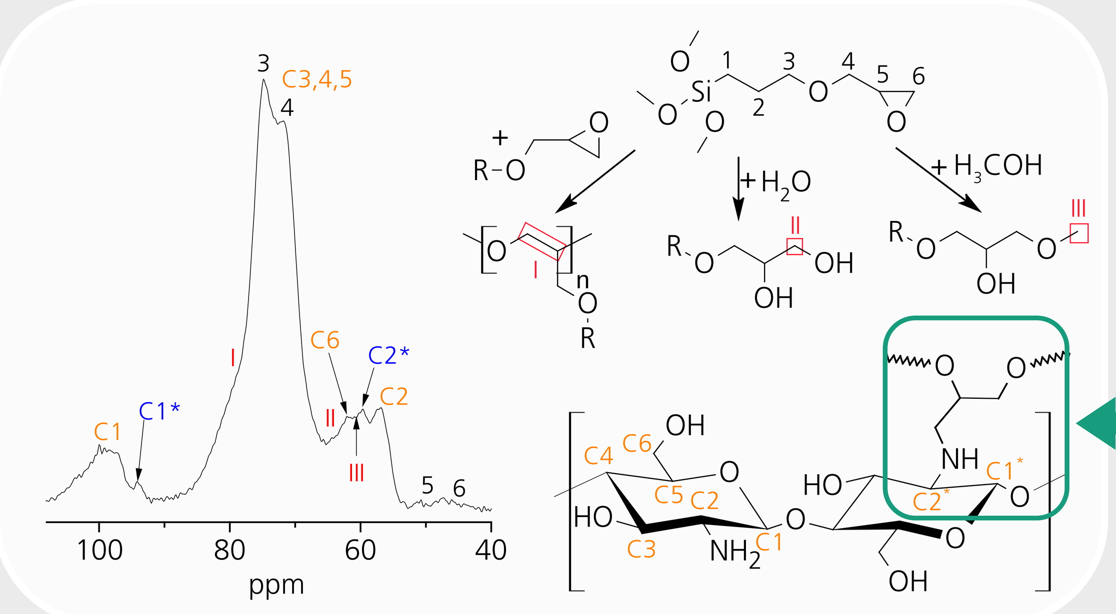
Hybrid materials (ORMOCER®s; Trademark of the Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. in Germany) as inorganic-organic hybrid polymers, synthesized by the sol-gel process can be applied as thin transparent coatings. These materials are known to fulfill the demands of packaging materials such as excellent barrier against water vapor, oxygen, carbon dioxide and odor especially in combination with inorganic layers like $SiO_x$. The unique features of ORMOCER®s are mainly based on the specific combination of properties of organic polymers with those of silicates or glass-like materials. Due to their promising properties this material class serves as a base for the development of new innovative biodegradable multi-functional coatings. Biodegradability was improved by modifying the ORMOCER® coatings with biodegradable precursor molecules while conserving good barrier properties [1]. Antimicrobial activity of the resulting coatings can be obtained by introducing functional additives like sorbic acid or zinc (hydr)oxide into the lacquer. The aim of the project was to trigger and control the antibacterial effect by the exposure to humidity.

## ORMOCER® containing chitosan

**Dissolution and incorporation of chitosan**

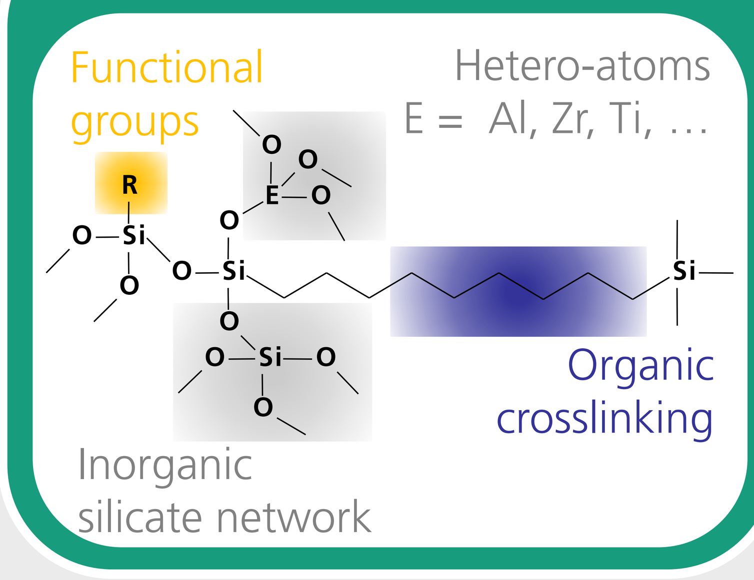



**Solid state $^{13}C$-NMR-spectrum** of ORMOCER® modified with chitosan



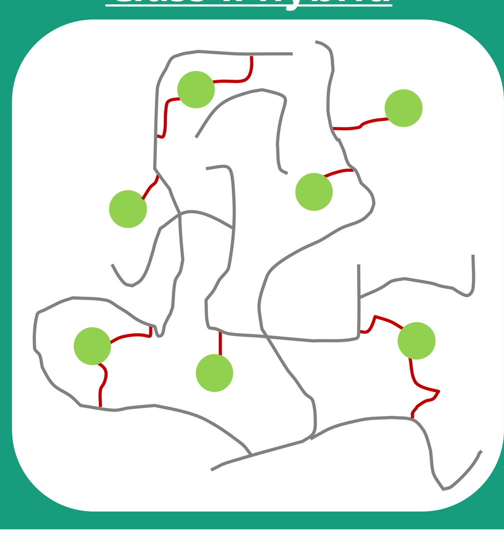

- Signal I confirms formation of covalent organic network
- Signal II and III caused by byproducts
- Signals C1* and C2* confirm covalent coupling of chitosan to the organic network of the ORMOCER® matrix
→ class II

## ORMOCER® structure




## Functional biodegradable hybrid materials

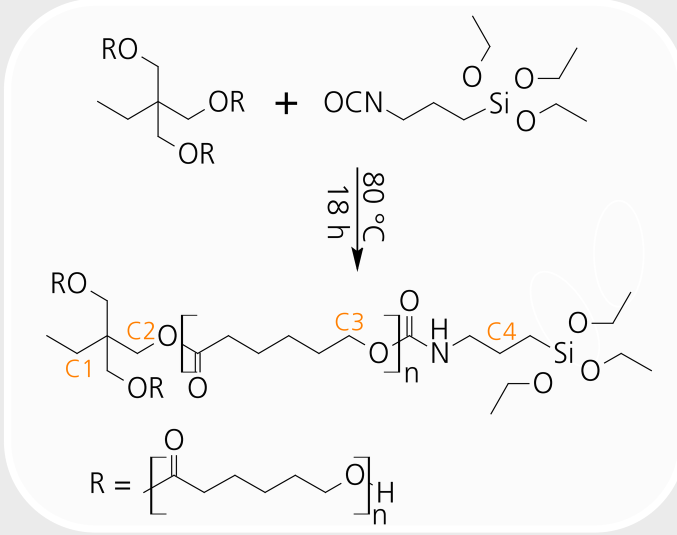
**Class II hybrid**



- biodegradable polymer
- covalent bonding
- ORMOCER®

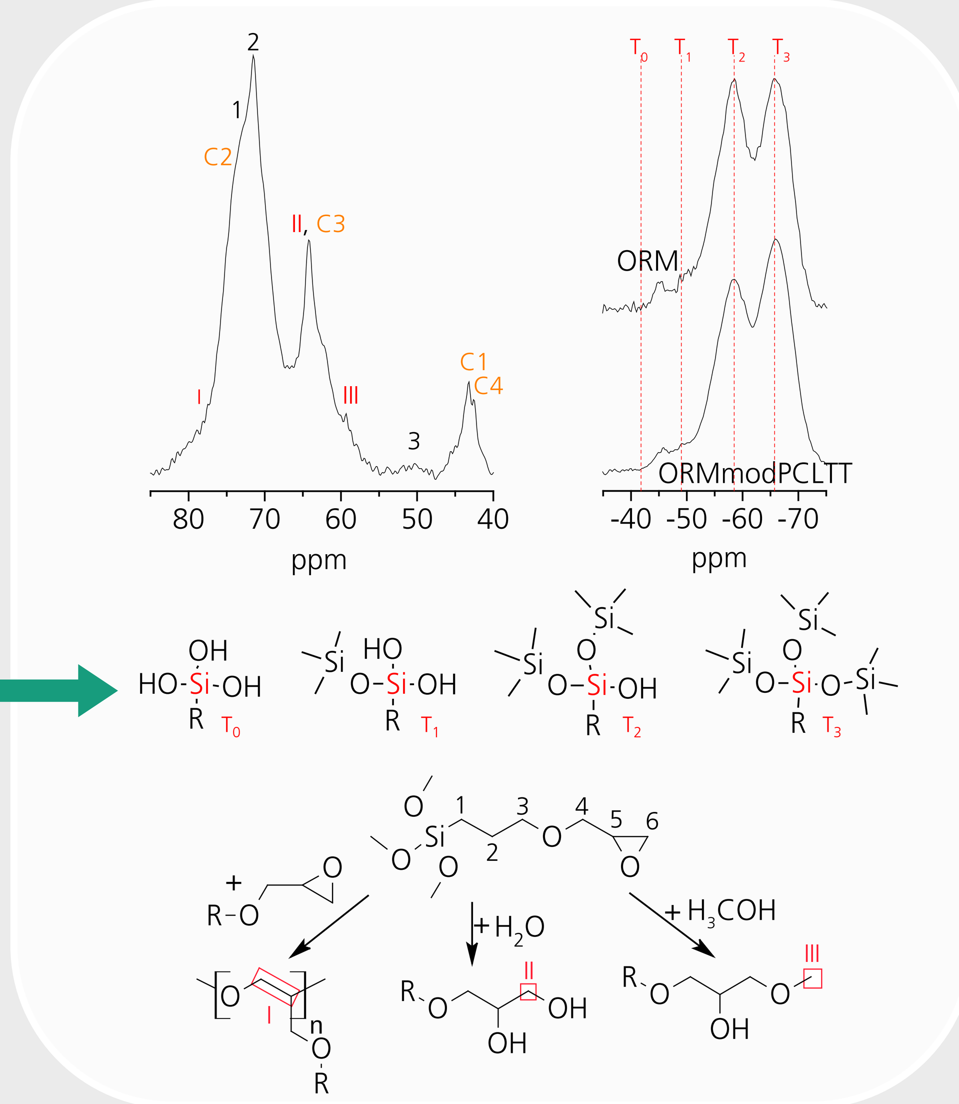
## ORMOCER® containing modified polycaprolactone triol (PCLT)

**Synthesis of polycaprolactone triol triethoxysilan (PCLTT)** [2]

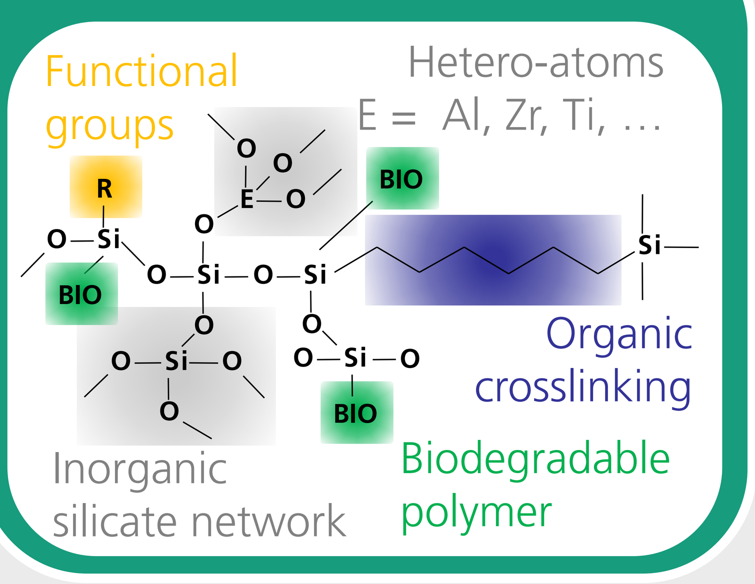



- Signal I confirms formation of covalent organic network
- Absent $T_0$ signal confirms covalent coupling of PCLTT to inorganic network

**Solid state $^{13}C$- and $^{29}Si$-NMR-spectrum** of ORMOCER® modified with PCLTT

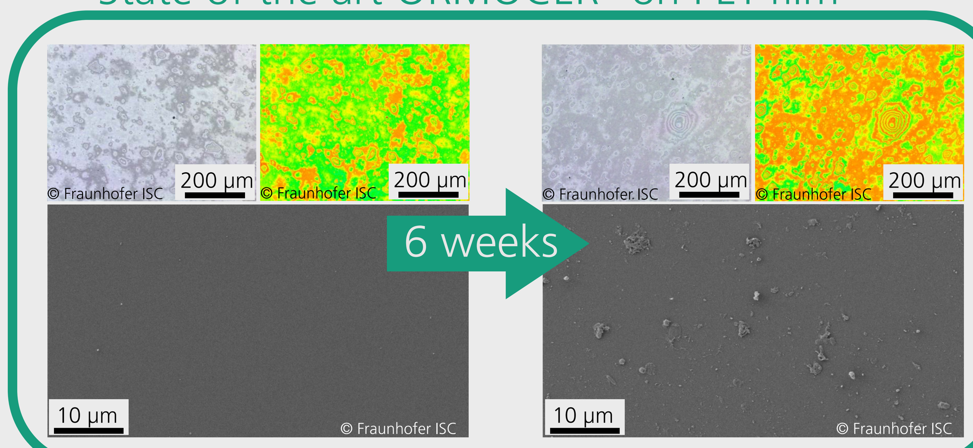



## bioORMOCER structure



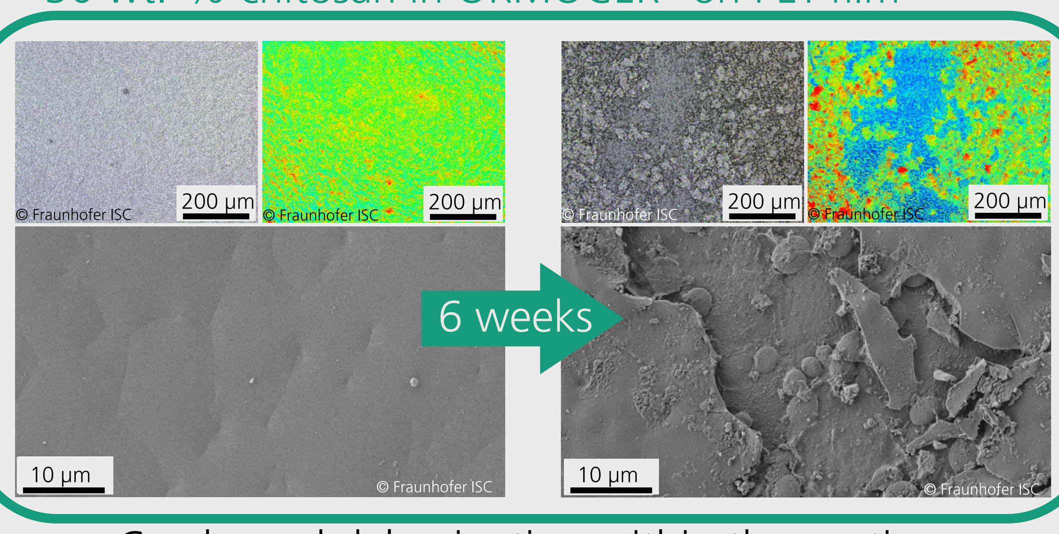

## Biodegradation and barrier properties

State of the art ORMOCER® on PET-film



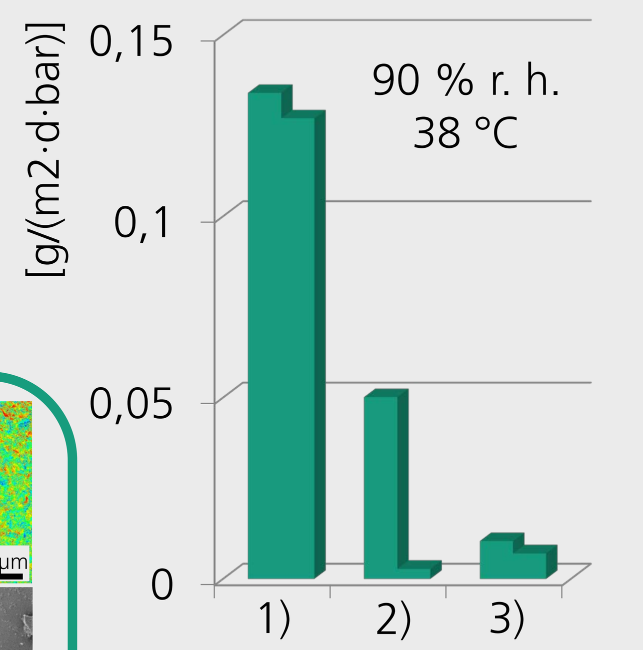

No observable degradation

30 wt.-% chitosan in ORMOCER® on PET-film




Cracks and delamination within the coating

**Water vapor transmission rates**

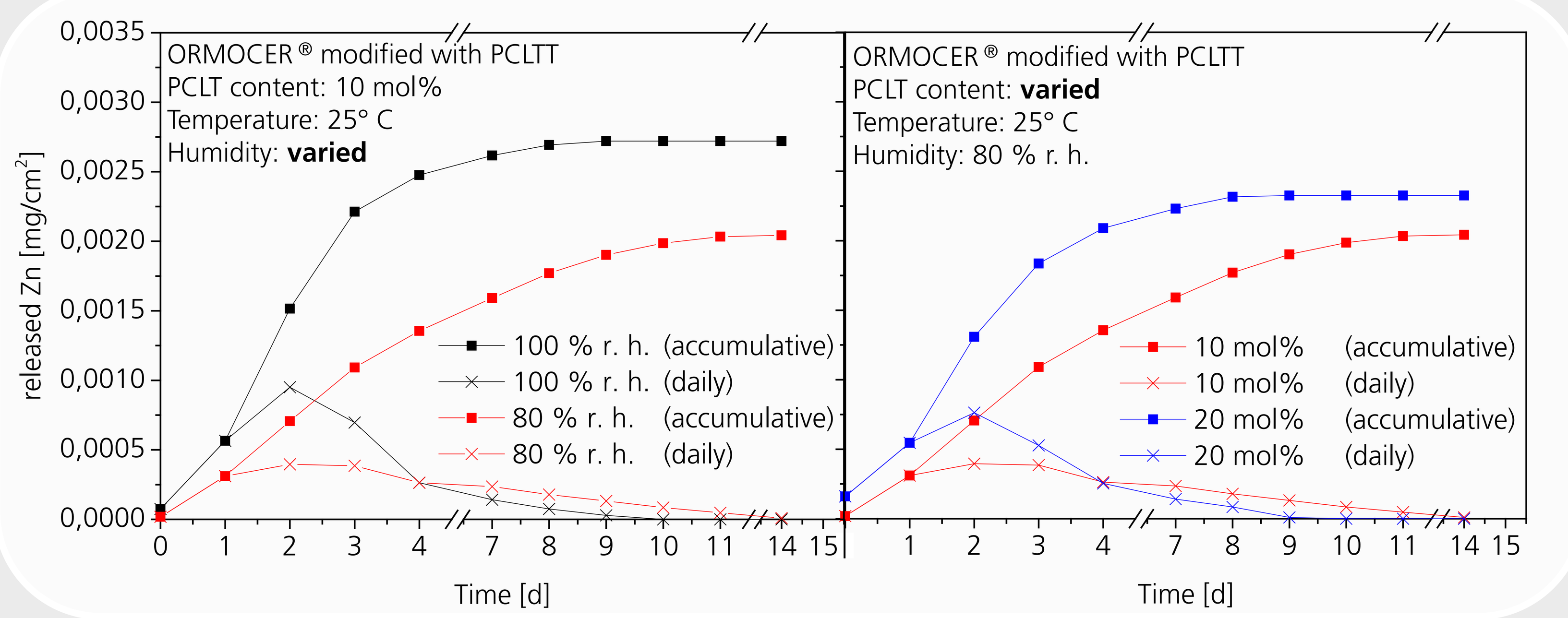



1) PET/$SiO_x$-film
2) ORMOCER® modified with 30 wt.-% chitosan
3) State of the art ORMOCER®

## Antibacterial release behavior

- Variation of the density of the network structure
- Variation in humidity and temperature
→ Variable release of antibacterial Zn

- Storage under controlled conditions
- Rinsing samples at defined intervals
- Analysis of washing phase by titration
- Humidity triggered antibacterial release




## Summary


- Incorporation of chitosan and modified biodegradable PCL-T into a barrier ORMOCER®
- Biodegradation results are promising
- Good barrier properties
- Humidity triggered antibacterial release can be varied by changes in network structure


## Outlook

- Optimization of antibacterial release behavior with regard to special needs of products
- Improvement of biodegradation

## Acknowledgement

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## Literature

[1] S. Koch: Development of biodegradable functional coatings for food packaging, *Poster contribution at Thüringer Grenz- und Oberflächentage*, Zeulenroda, Germany **2013**.
[2] P. Lui: Microstructure and thermal properties of silylterminated polycaprolactone-polysiloxane modified epoxy resin composites, *J. Appl. Polym. Sci.* 109 (**2008**), p.1105

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