Development of biodegradable functional coatings for food packaging

Susanne Koch[1,2], Daniela Collin[2], Sabine Amberg-Schwab[2], Gerhard Sextl[1,2]

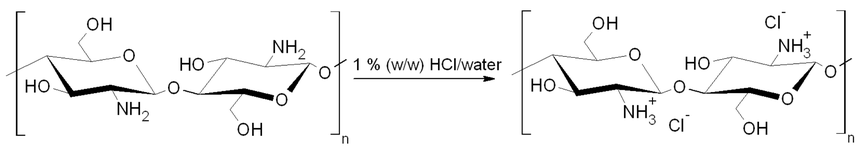
[1] Universität Würzburg, Lehrstuhl für Chemische Technologie der Materialsynthese, Röntgenring 11, 97070 Würzburg, Deutschland
[2] Fraunhofer-Institut für Silicatforschung, Neunerplatz 2, 97082 Würzburg, Deutschland

Introduction

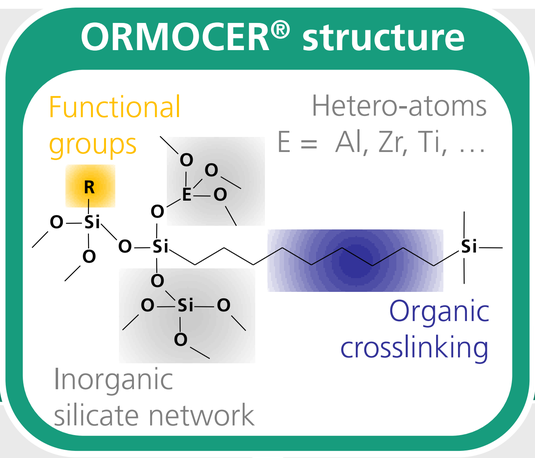
High-barrier coating materials based on ORMOCER®s (Trademark of the Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. in München) in combination with inorganic SiO_x-layers provide an excellent barrier against water vapor and oxygen. These inorganic-organic hybrid polymers are synthesized via the sol-gel process and have strong covalent bonds between the inorganic and the organic moieties. However, ORMOCER® materials are not adequate for the utilization as functional coatings for biodegradable packaging as these state of the art materials exhibit a poor biodegradability. Therefore, within this contribution a new class of ORMOCER® coating materials was developed, which shows biodegradability and high-barrier properties. These novel hybrid materials consist of an ORMOCER® coating modified by the biodegradable polymers chitosan and polycaprolactone.

Chitosan

Dissolution of chitosan

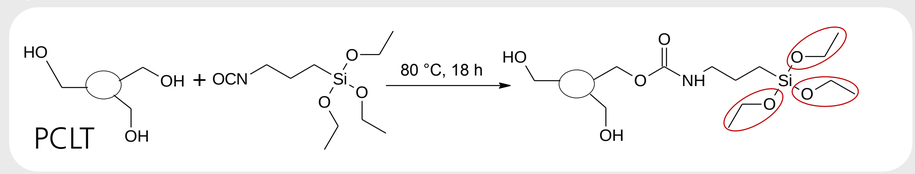


ORMOCER® structure



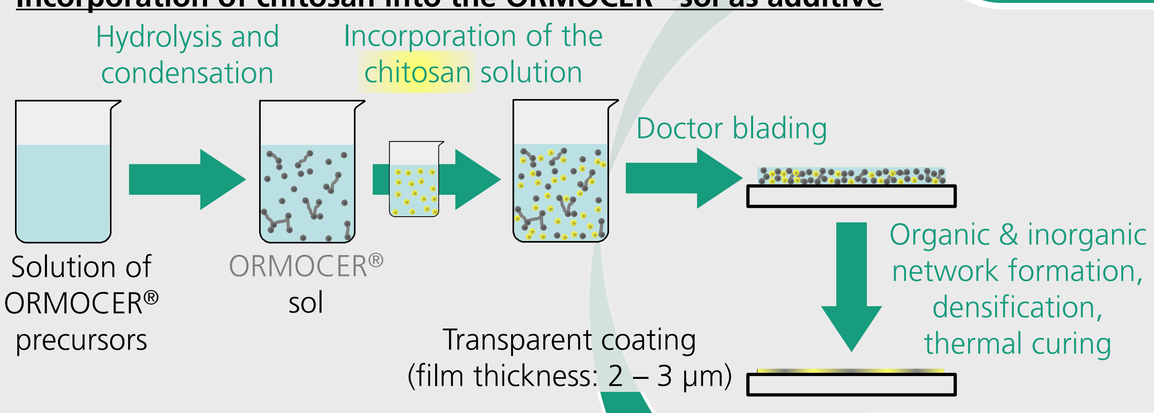
Polycaprolactone triol triethoxysilane (PCLTT)

Synthesis of PCLTT

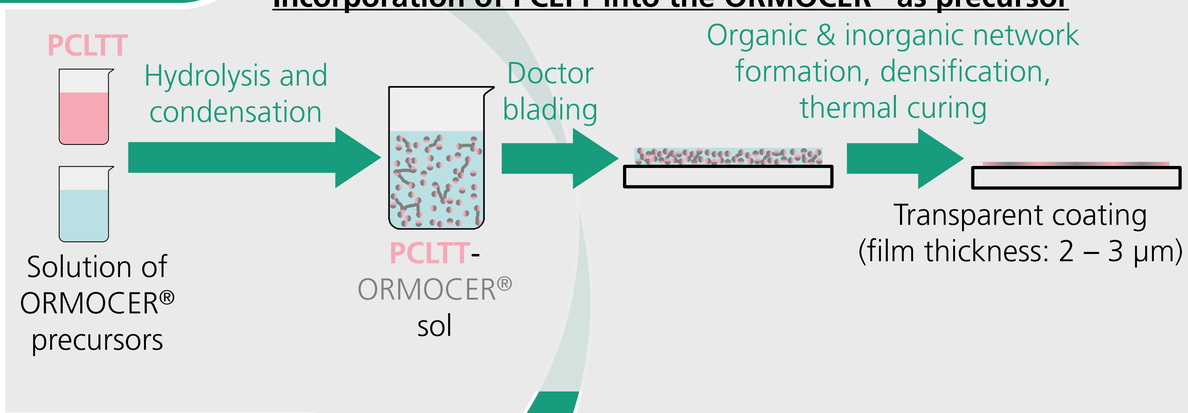


Functional groups for covalent coupling to the inorganic ORMOCER® network

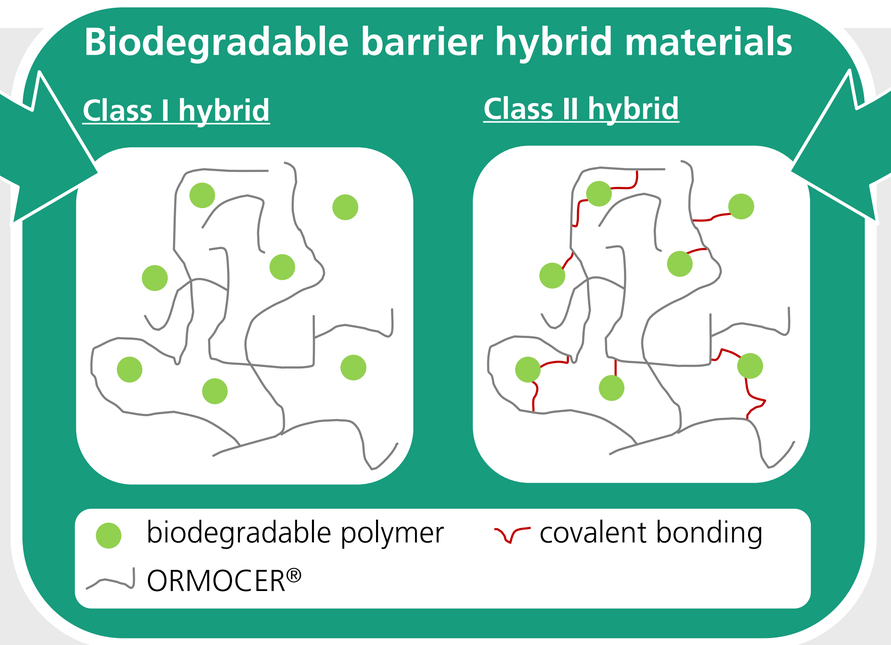
Incorporation of chitosan into the ORMOCER®-sol as additive



Incorporation of PCLTT into the ORMOCER® as precursor

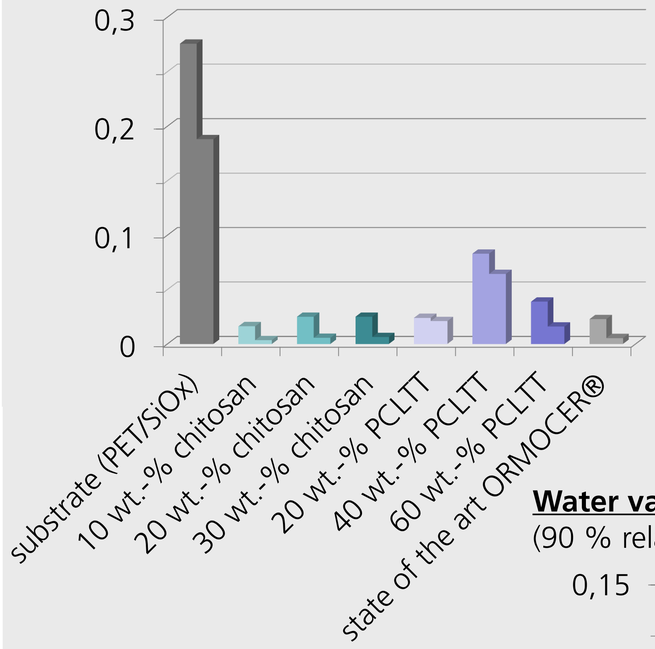


Biodegradable barrier hybrid materials

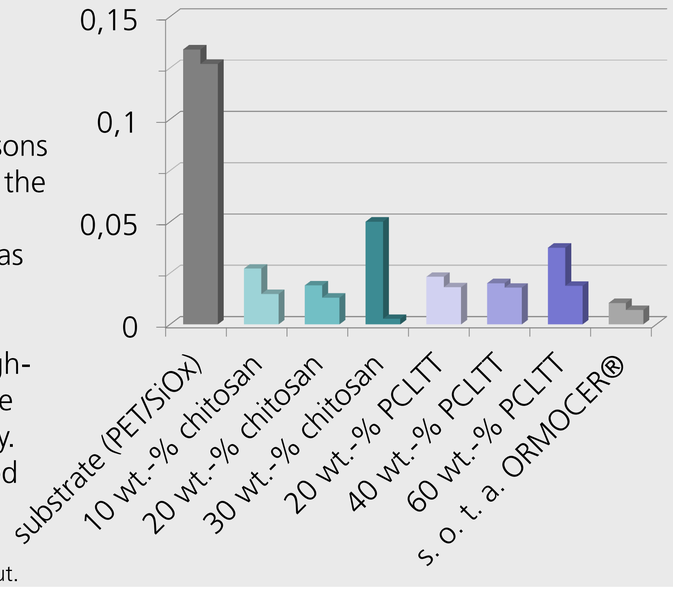


Barrier properties

Oxygen transmission rates* (DIN 53380-3)
(50 % relative humidity, 23 °C) in [$cm^3/(m^2 \cdot d \cdot bar)$]



Water vapor transmission rates* (DIN 53122-2)
(90 % relative humidity, 38 °C) in [$g/(m^2 \cdot d \cdot bar)$]



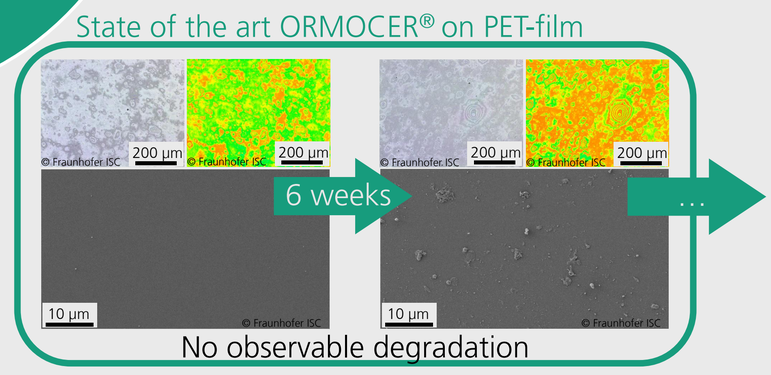
All coatings had been coated on PET/SiO_x-films. For comparison reasons the transmission rates in the case of the pure substrate and a state of the art ORMOCER® on PET/SiO_x are shown as well.

Compared to the state of the art high-barrier ORMOCER® the barrier of the novel coatings only decreases slightly. Therefore the coatings can be utilized for food packaging applications.

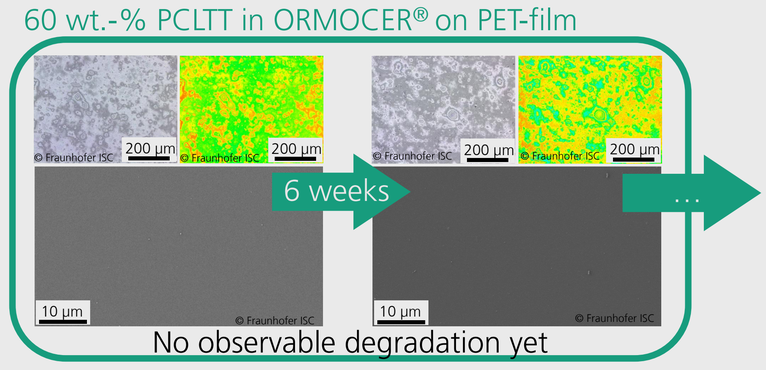
*For each sample two measurements were carried out.

Biodegradation via composting

State of the art ORMOCER® on PET-film

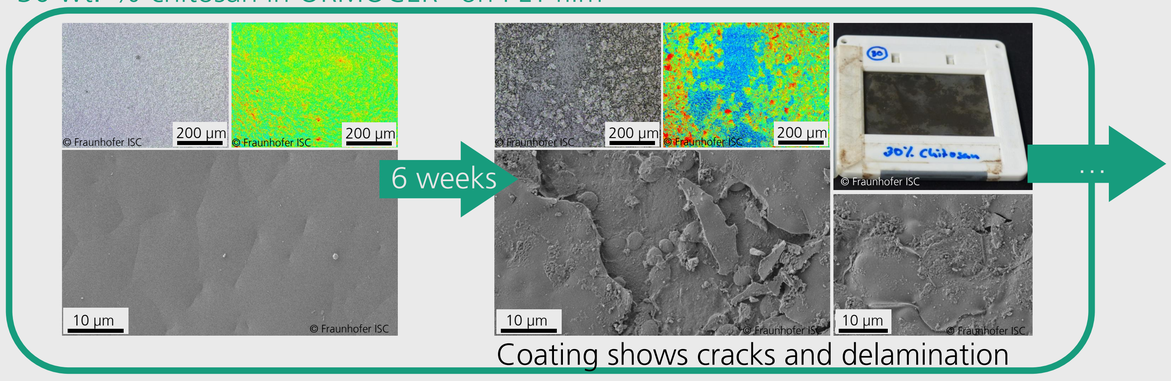


60 wt.-% PCLTT in ORMOCER® on PET-film



Height profiles of the coating surfaces (laser scanning microscopy):
0 µm — 4 µm

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



Summary

- Incorporation of modified biodegradable polymers into a high-barrier ORMOCER®
- Perpetuation of good barrier properties after insertion of biodegradable polymers
- First biodegradation results are promising

Outlook

- Optimization of barrier behavior and biodegradability
- Development of further functional properties of the coatings

Acknowledgement

This work has been part of the EU project DIBBIOPACK and was partially funded by a grant of Stiftung Industrieforschung (S. Koch). Additionally, the authors want to thank J. Prieschl, A. Burger and H. Bleicher for their practical support.

Literature

[1] S. Amberg-Schwab in S. Sakka: Handbook of Sol-Gel Science and Technology, Kluwer Academic Publisher, Massachusetts, **2005**, Vol. III: 455-478.

Fraunhofer-Institut für Silicatforschung ISC
Neunerplatz 2, 97082 Würzburg

www.isc.fraunhofer.de

Contact:
Dr. Sabine Amberg-Schwab sabine.amberg-schwab@isc.fraunhofer.de
Daniela Collin daniela.collin@isc.fraunhofer.de
Susanne Koch susanne.koch@isc.fraunhofer.de

Fraunhofer ISC