Development of biodegradable functional coatings for food packaging

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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 SiO₂-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

Incorporation of chitosan into the ORMOCER®-sol as additive

Hydrolysis and condensation
Incorporation of the chitosan solution

Doctor blading
OROMCER® solution

Transparent coating (film thickness: 2 – 3 µm)

Biodegradable barrier hybrid materials

Class I hybrid

Class II hybrid

Water vapor transmission rates* (DIN 53122-2) (90 % relative humidity, 38 °C) in [g/m²·d·bar]

All coatings had been coated on PET/SiO₂-films. For comparison reasons the transmission rates in the case of the pure substrate and a state of the art ORMOCER® on PET/SiO₂ 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.

Barrier properties

Oxygen transmission rates* (DIN 53380-3) (50 % relative humidity, 23 °C) in [cm³/m²·d·bar]

Incorporation of PCLTT into the ORMOCER® as precursor

Hydrolysis and condensation
Solution of ORMOCER® precursors

Ornamentation

Doctor blading

PCLTT

Transparent coating (film thickness: 2 – 3 µm)

Biodegradation via composting

State of the art ORMOCER® on PET-film

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

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

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Literature

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

Synthesis of PCLTT

Polycaprolactone triol triethoxysilane (PCLTT)

Incorporation of PCLTT into the ORMOCER®

Hydrolysis and condensation

Solution of ORMOCER® precursors

Doctor blading

PCLTT

Transparent coating (film thickness: 2 – 3 µm)

Functional groups for covalent coupling to the inorganic ORMOCER® network

ORMOCER® structure

Functional groups

Hetero-atoms

E = Al, Zr, Ti, ...

Inorganic silicate network

Organic crosslinking

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