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Modifications of WPI based coating by cross-linkers and electron beam treatment

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Introduction

In 2021, over 390 million tons of plastics were produced worldwide, of which only 1.5 % was biobased. Given the depletion of fossil resources needed to produce conventional non-biobased plastics, more sustainable alternative solutions are needed. This is particularly true for the packaging sector representing the largest market for plastics. Multilayer packaging is often used for food packaging in order to achieve the desired barrier properties with the lowest possible material input. However, these structures are usually not recyclable and can only be incinerated or landfilled. As a result, more sustainable packaging materials that have appropriate barrier properties and can still be removed are becoming increasingly important. Coatings based on whey protein isolate (WPI) are an example of this type of material. WPI based coatings can be applied on a variety of substrate films resulting in a significant reduction of the oxygen transmission rate (OTR). Moreover, the WPI based coating can be used as a separation layer for multilayer structures. The present study aimed to further improve the cross-linking of WPI coatings by using electron beam (eBeam) treatment and cross-linkers to achieve a further optimized oxygen barrier.

Experimental

For the coating, 8.5% by weight WPI was dissolved in deionised water prior to denaturation. After cooling, D-sorbitol was added as plasticiser in a 50 % (w/w) plasticizer-WPI-ratio. Finally, 5% of citric acid (CA) or 10% of trimethylolpropan-trimethacrylat (TMPTMA) cross-linking agents were added. The WPI-CA coating and the WPI-TMPTMA coating were applied on polyethylene terephthalate (PET) and polylactic acid (PLA), films, respectively. Following eBeam treatment at varying doses, OTR was measured according to ISO 15105-1 at 23°C and 50% relative humidity. Moreover, the WVTR was measured based on DIN 53122-1 at 23°C and 85% → 0% relative humidity.

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Results and Discussion

The WVTR of WPI coated PLA remained unaffected by the addition of TMPTMA as well as by eBeam treatment. As WPI coatings do not contribute to water vapour barrier due to their hydrophilic nature, these findings were expected. In contrast, upon eBeam irradiation, the OTR decreased with increasing doses. However, this trend was accompanied by an increase of the standard deviation indicating the formation of defects within the WPI layer with increasing doses. The addition of the cross-linking agent TMPTMA reduced the OTR by a factor of 2.3 (14.9 cm^3/m^2 d bar) compared to PLA coated with WPI only (34.0 cm^3/m^2 d bar). Subsequent eBeam treatment with doses up to 30 kGy resulted in a further decrease of the OTR by a factor of 1.5 for the TMPTMA containing coating.

In contrast, for WPI coated PET, both irradiation and the addition of CA as a cross-linking agent were found to reduce the WVTR. However, the combination of both did not further reduce the WVTR. In contrast to WPI coated PLA, the OTR of PET films coated with WPI was not affected by eBeam irradiation. However, upon addition of CA, the OTR decreased by a factor of 1.3 from 5.2 to 3.9 cm^3/m^2 d bar. Interestingly, upon eBeam treatment, the OTR of PET coated with WPI-CA slightly increased.

Conclusions

The WVTR of WPI coated films only showed minor changes upon the addition of cross-linking agents and/or eBeam treatment. These findings are not surprising as WPI coatings are not reported to contribute to the WVTR due to their hydrophyilic nature. On the other hand, regarding the OTR of said films, the effect of eBeam treatment may vary depending on the substrate film and the stability of the coating itself. The addition of cross-linking agents further reduced the OTR in any case. This indicates that the cross-linking agents are compatible for the applications in WPI based coatings and do enhance the cross-linking reaction within the coatings itself.

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Biography

Kristina Eissenberger (female) holds a bachelor and master degree in Biology from the Ludwig-Maximilian University Munich as well as a Doctor’s degree from the University of Hohenheim. As research group leader at the Sustainable Packaging Institute at the Albstadt-Sigmaringen University, she is actively involved in the writing of research proposals in the field of sustainable packaging concepts. Moreover, she

is also actively participating in several multinational research projects, where she also acts as scientific and technical coordinator.