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Nanoscale surface hydrophobization of whey protein based films

Sustainable Packaging Institute SPI

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1 Introduction

In conventional packaging concepts multilayer structures often use to provide the required functionality tailored to the packaging goods. These are generally not biodegradable and difficult to recycle. Therefore, the development of more sustainable and bio-based multilayer composite materials are required in following projects: BiOnTop, Preserve and BioSupPack.

The coating with whey protein as an oxygen barrier is a bio-based alternative to the conventionally used ethylene-vinyl alcohol co-polymers (EVOH). However, the barrier properties decrease with increasing humidity due to the hydrophilic character of the whey protein coating. Therefore, functionalization of the coating is required.

One method of a nanoscale surface hydrophobization of hydrophilic substrates is the chemical fatty acid grafting technique. In this process, fatty acids are covalently bonded onto the surface of the substrate, improving the water vapour barrier and water repellent properties.

2 Materials and Methods

In the project BiOnTop the fatty acid grafting of the WPI (Whey protein Isolate) films with the transfer method was conducted using different fatty acid chlorides (myristoyl chloride (C14), palmitoyl chloride (C16), stearoyl chloride (C18)) and anhydride (palmitic anhydride). The grafting temperature was tested between 60°C - 160°C and the grafting time was set constantly to 10 min based on previous investigations. [1), 2), 3), 4)]

Therefore, the fatty acid chlorides and the anhydride are dissolved into a solvent. A transmitter paper is wetted in the fatty acid solution after which the solvent evaporates from transmitter. Then, the transmitter paper is placed on the top of the whey protein based film and put into an oven for a set temperature and time. In this process step the esterification of the fatty acids onto the surface of the substrate occurs. [1), 2), 3), 4)]

The method of fatty acid grafting via transmitter paper is schematically illustrated in figure 1. The fatty acid grafting was analyzed by measuring the water vapour permeation (WVTR at 23°C, 50% 0% r. h.) and the contact angle against water.

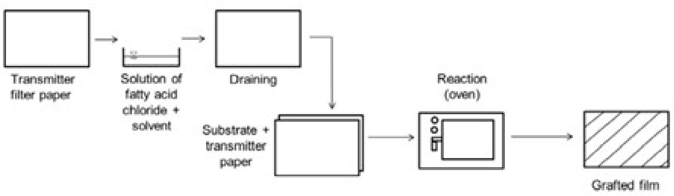

Figure 1: Chemical grafting process via transmitter paper (adapted from[1)])

3 Results and Discussion

The results of grafting of the WPI based films with fatty acid chlorides indicate an improvement in the water vapour barrier. In figure 2 the results of the WVTR are illustrated. The WVTR values of the WPI films grafted with fatty acid anhydrides indicate a small improvement in the barrier values (Barrier improvement factor 1.4 (BIF)). However, due to the high standard deviation, no significance can be determined. This is due to the low reactivity of the palmitic anhydride. [4)] The results of the WVTR of the samples grafted with the three fatty acid chlorides consistently show an improvement of the WVTR with increasing temperature. The highest barrier improvement was measured for the films grafted at 160°C with stearoyl chloride (C18) (BIF 4.8). This indicates that the water vapour barrier could be increased by both factors using fatty acids with a higher chain length and using increased grafting temperatures.

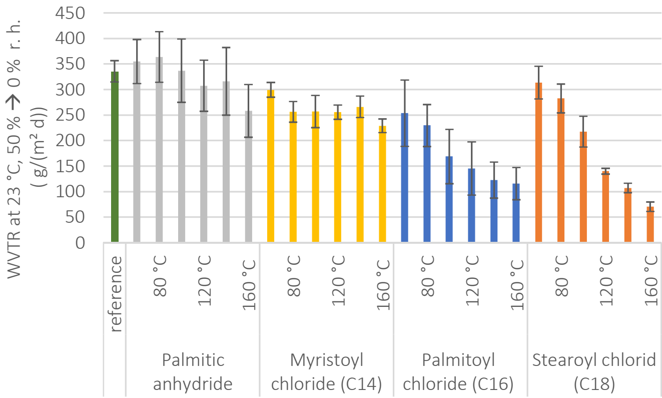

Figure 2: WVTR of grafted WPI castfilms (transfer method)

The water contact angle of palmitoyl chloride (C16) grafted samples was measured. The reference and the WPI based films grafted with the anhydride could not be measured based on the rapid spreading of the water drop into the WPI based films. The contact angles of the grafted WPI based films ranged between 92° and 102°. The results of the contact angle of the grafted WPI films are comparable with contact angle measurements of paper coated with PVOH and grafted with the transfer method (90°-106°) [3)]. In contrast to the samples grafted with palmitoyl anhydride and the reference (a), the WPI films grafted with palmitoyl chloride (b) showed a clear hydrophobic effect (Figure 3).

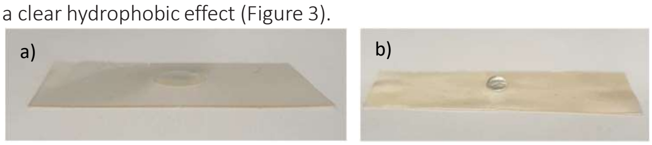

Figure 3: Water drop on the surface of a non grafted WPI film (a) and a grafted WPI film (160°C, 10 min) (b)

4 Further results on the topic of nanoscale surface functionalization are available in the following recently launched EU projects:

biontop
H2020-BBI-JTI-2018
GA 837761

PRESERVE
H2020-NMBP-TR-IND-2018-2020
GA 952983

BIO SUP PACK
H2020-BBI-JTI-2020
GA 101023685

For more information go to our website: www.hs-albsig.de/spi

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This project has received funding from the Bio-based Industries Joint Undertaking (JU) under the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 837761. The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Bio-based Industries Consortium.
This publication reflects only the author's view and that the Commission is not responsible for any use that may be made of the information it contains.

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