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Properties of Biodegradable Multilayer Films Based on Plasticized Wheat Starch

Multilayer films based on plasticized wheat starch (PWS) and various biodegradable aliphatic polyesters have been prepared through flat film coextrusion and compression molding. Poly(lactic acid) (PLA), polyesteramide (PEA), poly(ε-caprolactone) (PCL), poly(butylene succinate adipate) (PBSA), and poly(hydroxybutyrate-co-valerate) (PHBV) were chosen as the outer layers of the stratified "polyester/PWS/polyester" film structure. The main goal of the polyester layers was to improve significantly the properties of PWS in terms of mechanical performance and moisture resistance. Since no specific compatibilizer or tie layer were added, the properties of subsequent films rely on the compatibility between the respective materials only. The effects of glycerol content in PWS, polyester type, and film composition on the mechanical properties and adhesion strength of multilayers were investigated. The conditions for optimal product performance were examined. The multilayer films may be suitable for applications in food packaging or disposable articles.

Keywords: Plasticized wheat starch; Polyesters; Multilayer structures; Adhesion strength

Research Paper

1 Introduction

Over the last decades, there has been growing needs to find alternatives to petroleum-based products because of environmental concerns. Starch is an inherently biodegradable, renewable and low-cost material, and has high potential in food or non-food applications [1]. In that respect, the applications of starch have given rise to a great number of studies [2–5]. Native starch, when plasticized with glycerol and water, can be processed by conventional extrusion techniques, and will be referred herein as plasticized wheat starch (PWS).

Unfortunately, there are some strong limitations to the development of starch-based products, due to its poor mechanical properties and high sensitivity to moisture. One strategy to overcome these weaknesses is to associate starch with a moisture resistant polymer with good mechanical properties, while maintaining the overall biodegradability of the product. We have melt-blended PWS together with various biodegradable polyesters, such as poly(ε-caprolactone) (PCL) [6], poly(lactic acid) (PLA) [7], poly(butylene succinate adipate) (PBSA) [8], and polyesteramide (PEA) [9]. Blending PWS with these polyesters resulted in a significant improvement of the properties of plasticized starch. However, although a "protective" polyester skin layer was formed at the surface of most blends during injection molding [6–9], the moisture sensitivity of plasticized starch was not yet fully addressed. In an effort to develop the applications of starch, coating PWS with hydrophobic biodegradable polyester layers should be preferred. Multilayer coextrusion has been widely used in the past decades to combine the properties of two or more polymers into one single multilayered structure [10–12]. To date, there has been only few published studies reporting the use of plasticized starch and polyesters in coextrusion [13, 14] and some examples have been described in the patent literature [15–17]. The preparation of starch-based multilayers may also be carried out through compression molding of plasticized starch and polyesters. This technique has been used by *Hulleman* et al. [18–20] to shape plasticized starch into low thickness disks or films, and they studied the properties of subsequent compression molded materials. Although coating water-resistant polyesters on molded starch substrates was disclaimed [21], no published studies investigated the use of multi-step compression molding to prepare stratified products with plasticized starch as the central layer.

In this work, the properties of "plasticized starch-polyester" coextruded and compression molded films are reported. Besides the PWS and polyester components, no specific compatibilizer or tie layer were used. The effects of the film composition, polyester type and plasticizer content in PWS on the adhesion strength between respective layers were examined. Finally, the conditions to improve the adhesion between layers are critically discussed.

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