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Current Progress on Biodegradable Materials Based on Plasticized Starch

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This paper presents some current progress on biodegradable materials that are based on plasticized starch (PLS). To improve the hydrophobic character of the material for packaging applications, for example, a recent and promising development based on a PLS–biopolyester (e.g. polycaprolactone) blend with plasma-coated SiO_x is presented. PLS–biopolyester blends can show, under certain processing conditions, a pseudo-multilayer structure with a polyester skin that allows good adhesion of SiO_x deposits. XPS and FTIR-ATR determinations are used to assess the outer surface.

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It is increasingly clear that the use of long-lasting polymers for short-lived applications (such as in packaging, catering, surgery, or hygiene applications) is not entirely adequate and leads to unjustifiable pollution. The potential uses of biodegradable and renewable polymers obtained from agro-resources (e.g. the polysaccharides) has long been recognized. Thus far, agro-polymers such as starch are largely used in food industry applications but have not found extensive applications in, for example, the packaging industry to replace conventional plastic materials.

Native starch can be transformed in thermoplastic-like polymers after destructuration and plasticization processes. Plasticized starch (PLS) totally decomposes into nontoxic residues, is derived from renewable resources, and is relatively inexpensive compared to synthetic thermoplastics. Moreover, compared to fossil-derived materials the price of starch remains stable and even tends to decrease. PLS can be easily processed and, according to its formulation, presents a wide range of properties. Unfortunately, PLS is very moisture sensitive and, compared to synthetic polymers, mechanically rather weak. To overcome these issues, two main strategies, chemical and physical, have been explored. Starch modification (chemical strategy) has been in development since the early 20th century. Starch esterification (e.g. by acetylation) improves the water resistance. This chemical strategy does have limits, such as in the toxicity and the diversity of the byproducts obtained, and chemical reactions can lead to reduction of the polysaccharide's molecular weight. Such products do not fulfil the requirements for introducing PLS into materials applications. The alternative physical strategy has been in development since the 1980s. It is based on the association of PLS with other biodegradable compounds such as biodegradable polymers, 'agro-fillers', to obtain compositable multiphase materials, such as blends, multilayers, composites, and nanocomposites.

Blending is the easiest process to associate different polymers together, and provides a powerful route to obtain materials with improved property–cost performance and is cheaper than developing new polymers. PLS has been widely used in blends with other polymers.[1,2] Considerable research efforts have led to starch-based blends being commercialized, such as 'Mater-Bi' (Novamont).[3] To produce these commercial blends, starch is blended with non-biodegradable polymers (polyolefins) or with biodegradable polyesters (e.g. polycaprolactone, PCL). To maintain the decompostability feature, most research is focussed on blending PLS with biodegradable polyesters (biopolyesters).[1,2] These commercially available biopolyesters show some interesting properties such as increased hydrophobicity, decreased water permeability, and, compared to PLS, improved mechanical properties. In certain conditions without compatibilizer, we have shown[4] that after injection moulding (during cooling) we obtain polyester migration toward the surface due to phase separation. We achieve a pseudo-multilayer structure with a starchy core (Fig. 1). This phenomenon is attributed to a large difference in the viscosities of the molten components, which is accentuated when compatibility between the components is poor. To minimize the energetically unfavourable interactions

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