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Use of fatty acid starch ester as hydrophobizing agent in extruded thermoplastic starch material

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PURPOSE OF THE ABSTRACT

Replacing petrochemical materials with bio-based materials in short-life products, such as food packaging, is one of the biggest challenge of the 21th century, as improved by Cop23 concern, especially the awareness of the material end-of-life management and the universal need to respect the environment. The bio-based plastics market expects 19% growth per year until 2025, especially in food packaging, where material specificities must be respected to insure food conservation: specific gas and water permeability and stable mechanical properties depending on the environment.

Even if our Research team is able to control starch plasticization by extrusion (1,2) and conception of starch-based biodegradable and active films with antimicrobial (3) or oxygen scavengers properties (4), starch alone cannot meet all the criteria of food packaging. In fact, its high sensitivity to moisture and biochemical or biological degradation makes it a good candidate to develop a biodegradable material but limits its use for food packaging. Moreover the dry thermoplastic starch (TPS) is known for its good properties of barrier to oxygen but these properties decrease when TPS absorbs water so to limit the hydrophilicity of TPS is a major issue to facilitate its use as food packaging.

Our point of view was to engage a step-by-step strategy to modify TPS properties, and we propose first to overcome moisture sensitivity problem, by associating the thermoplastic extruded starch with a hydrophobic starch-based polymer, especially fatty acid starch esters (FASEs).

According to our previous work based-on the determination of FASEs structure-properties relationship (5), we decided to use fully substituted starch laurate as starch-based polymer, to induce a hydrophobic behavior to TPS. This FASE was synthesized under continuous stirring using lauroyl chloride (8 equiv. per anhydroglucose unit) in pyridine (10mL/g of starch), at 90°C for 3h. FASE was purified by alcoholic precipitation and filtration. The crude solid product was twice solubilized and precipitated with chloroform and methanol respectively. After drying, starch trilaurate was analyzed mainly by FT-IR and 1H NMR spectroscopies to assess the efficiency of reaction and confirm the full substitution of hydroxyl groups of the polysaccharide by fatty chains, especially by substitution degree determination.

The obtained starch trilaurate was then introduced at 2%, 5% and 10% in the formulation of thermoplastic starch (wheat starch with 20% glycerol) and films were carried out by double extrusion (first extrusion for

compounds, second extrusion for films). Films were subjected to several physico-chemical analyzes, including thermogravimetric analyses, contact angle measurements and tensile tests, in order to evaluate their properties and the influence of FASE content on these characteristics.

If no real variation of thermogravimetric results were observed according to FASE ratio, FTIR analyses of these films show that FASE move preferentially towards the film surface, whatever the FASE ratio. This result can explain the improvement in TPS surface hydrophobicity, observed thanks to contact angle measurements, which show an increase of the contact angle with the rate of starch trilaurate in the TPS film, as presented in the figure 1.

Concerning tensile test applied to materials, the presence of FASE in TPS films leads to a decrease of the maximal tensile strength and the drop down of the tensile strain and allows to decrease the variation of the mechanical properties of these films with the humidity rate.

The starch modification process developed allows to successfully synthetized hydrophobic starch trilaurate and this product can be blended with thermoplastic starch to obtain homogeneous films. This association leads to more hydrophobic films that could be used as food packaging materials.

FIGURES

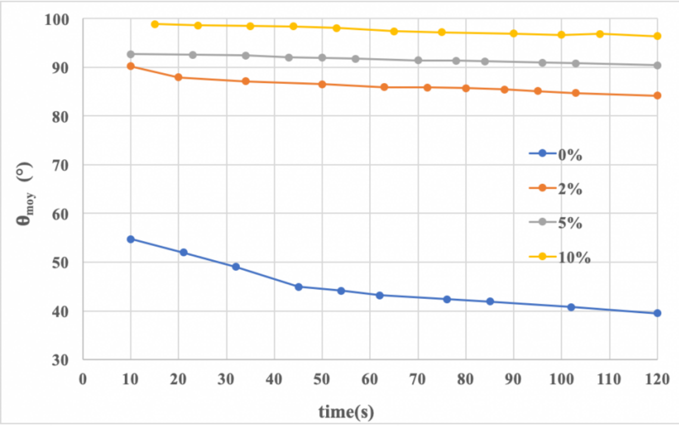

FIGURE 1

Evolution of average contact angle as function of time, for TPS blended with 0% 2%, 5% and 10% of fully lauroylated FASE

FIGURE 2

KEYWORDS

Bio-based material | thermoplastic starch | Hydrophobicity | physical properties

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