The effect of montmorillonite chemical composition and extrusion process on a novel starch bio-nanocomposites for food packaging

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Chemical and physical modification of starch and/or addition of nanofillers, such as montmorillonite (MMT), have proved to be a promising approach to enhance starch performance. The main objective of this work was to obtain montmorillonite-filled starch bio-nanocomposites by extrusion process with improved performance for food packaging. Native cassava starch and modified by dry heating treatment were used as polymer matrix. Natural sodic montmorillonite was superficially modified using alkylpolyglucoside bio-surfactant (APG) to prepare organo-montmorillonite (OMMT). First, all components, including water and glycerol, were premixed in solid-state. Then, starch bio-nanocomposites were produced in two extrusion steps using a co-rotating twin-screw extruder at 100 rpm and temperature profile between 65 and 110 ºC. The extrusion process was also studied in order to compare the effect of each step on material properties. Structural properties of nanocomposites were accessed by X-ray diffraction. The reinforcement effect and material performance were evaluated by water resistance, opacity and barrier, thermo and mechanical properties. Dispersion of MMT resulted in bio-nanocomposites with intercalated structure. Nanocomposites from the first step featured a less-ordered structures. Nevertheless, the clay mineral was successfully modified by APG, increasing the interlayer space and compatibility with starch. As a result, OMMT was better dispersed and reached nanocomposites with partial exfoliated structure. Overall, starch properties were enhanced by addition of the nanofillers, mainly by OMMT. The main results revealed that water permeability and resistance were enhanced by 43 % and 32 %, respectively. Tensile strength and Young modulus of unfilled starch increased from 0.68 and 3.23 MPa to up to 2.31 and 14.24 MPa, respectively, by filling with OMMT. Oxygen permeability and opacity of the sheets were also greatly improved by nano-reinforcement. Furthermore, the melting peak of nano-structured starch increased by more than 15 °C when compared to starch, suggesting the formation of more well-organized crystalline structures. However, no significant difference was observed in thermal degradation behavior of the materials. As conclusion, the MMT modification by the bio-based surfactant is a good approach to enhance dispersion/interaction with starch matrix. The bio-nanocomposites developed in this work, with improved properties, is a feasible eco-sustainable alternative for food packaging applications.