Enzyme-mediated tuning of cellulose surface reactivity for innovative compounding purposes

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In the last decades biopolymers produced from natural sources (plants, animals, microorganisms) have gained popularity thanks to their outstanding properties. Cellulose, the most abundant biopolymer on Earth, is attracting attention because of its excellent physical and chemical properties, being also sustainable, renewable, and biodegradable. The intrinsic high crystallinity makes cellulose a promising reinforcing material in the formulation of elastomeric compounds. Nevertheless, modifying cellulose functional hydroxylic groups while preserving its crystalline structure is crucial for ensuring material compatibility. In this study, a lipase-mediated approach was exploited for the acylation of cellulose hydroxyl groups. The formation of the esteric bonds was confirmed through Attenuated Total Reflectance Fourier-Transform Infrared (FTIR-ATR) analysis and Thermodesorption - Gas Chromatography - Mass Spectrometry analysis (TD-GC-MS), whereas Wide-Angle X-Ray Diffraction (WAXRD) and Thermogravimetric Analysis (TGA) were used to verify the retention of crystallinity pattern and the polymer thermal stability, respectively. Subsequently, the modified cellulose was incorporated into a model elastomeric compound, with a commercial peroxide used as the vulcanizing agent. The mechanical and dynamic mechanical properties of the compound were tested, resulting in a general reinforcement of the system. In comparison to a control test using non-derivatized cellulose, the modified polymer exhibited increased stress at break and decreased tan delta, clearly indicating the compatibilization of cellulose through the tuning of functional group reactivity.