Visualization of the impregnated layer in polymer-coated cardboards

Allison Vercasson*[1], Joao Paulo Cosas Fernandes[2], Sébastien Gaucel[1], Nathalie Gontard[1], Valérie Guillard[1], and Hélène Angellier-Coussy[1]

[1]Ingénierie des Agro-polymères et Technologies Émergentes – Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement, Institut Agro Montpellier, Université de Montpellier – France

[2]Centre de Recherches sur les Macromolécules Végétales – Institut de Chimie du CNRS, Centre National de la Recherche Scientifique, Université Grenoble Alpes – France

Résumé

Papers and cardboards appear to be excellent candidates as substitutes for conventional plastics in food packaging. However, their poor barrier properties hinder their use for various applications. To overcome this, their surface can be coated with a thin layer of high-barrier polymer. Due to the paper intrinsic porosity, a part of the coated polymer unavoidably penetrates within the cellulosic substrate leading to a complex multi-layered structure with at least three layers, i.e., a polymer coating layer (polymer that does not impregnate), an impregnated layer, and a non-impregnated substrate. Characterizing the level of impregnation is crucial to formalize structure/properties relationships in such materials, which remains challenging. Scanning electron microscopy (SEM) is the most largely used technique to observe materials cross-sections but require a neat cut of the cross-section to allow a good visualization of material's layers, which is a tricky step for porous substrates.
In this context, this study aims to select a cutting method allowing the multilayered structure visualization by SEM and the assessment of the impregnated layer's thickness. To do so, a range of coated cardboards with different impregnation levels, were prepared: a commercial cardboard was selected as reference and an untreated blotting paper was considered to emphasize the polymer impregnation phenomenon. Two polymers were used as coating: PHBV, poly(3-hydroxybutyrate-co-3-hydroxyvalerate), a bio-based and biodegradable polymer, and LLDPE, linear low-density polyethylene, a conventional polymer, as benchmark.
Different cutting techniques (scissors, razor blade, manual cryofracture, (cryo)-ultramicrotome) have been tested. Cutting using a cryo-ultramicrotome was the only method allowing an accurate visualization of all three layers of the material by SEM. Without cryoscopic conditions, only the coating layer was clearly visible. To overcome this challenging cutting step, X-ray microtomography, which allows samples 3D visualization without needing a neat cut of the sample, was also investigated. However, X-ray tomography cross-section views did not allow such precise visualization of all three layers thickness, resulting in a greater experimental error for impregnated layer thickness determination.

*Intervenant