

Sustainability Assessment of Active Packaging Incorporating Nanomaterials

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ABSTRACT (English)

Packaging plays an important role in ensuring food safety and quality, and the development of active packaging, especially antimicrobial packaging, enables actively inhibiting/killing the microorganisms causing food spoilage, and thus extending the product's shelf life. Generally, 50% shelf life extension is possible. The interest for using metal containing nanoparticles for active packaging derives from its superior antimicrobial efficacy and no negative impact on the food sensory properties.

In this thesis, the packaging material of concern is a PLA (Polylactic Acid) coated paper incorporating zinc oxide nanoparticles (ZnO NPs) in the coating layer. The material was characterized and its antimicrobial activity was evaluated. The SEM images show that the nanoparticles were homogeneously distributed across the surface thanks to its surface modification. Antimicrobial assay indicates that the active material was effective in inactivating *E. coli* and *S. aureus*. Furthermore, *E. coli* was found to be more susceptible to this type of agent, showing 3.14 log reduction for 0.5 wt% agent loading in PLA coating layer. This result was compared across the publications using the same agent for treating both Gram-positive and Gram-negative microorganisms. The discrepancy between the results can be explained by the fact that ZnO nanoparticles have multiple action mechanisms, and different antimicrobial testing methods may stimulate part of the action mechanisms.

On the other hand, for paper and paperboard packaging recyclability plays an important role in conserving the resources and reducing the environmental impacts. Therefore, when it comes to the nano-enabled paper packaging material, the recyclability issue should be properly addressed. The recyclability test was carried out in a lab-scale paper recycling line. The protocol was based on a method adapted from ATICELCA MC501-13, which enabled to recover over 99% of the solids material. The mass balance result indicates that 86%-91% zinc oxide nanoparticles ended up in the rejected material stream, mostly embedded within the polymer coating; whereas 7%-16% nanoparticles ended up in the accepted material stream. Besides, the tensile strength of the recycled handsheets suggests that the nano-enabled coating had no negative impacts on the recovered fiber quality.

Active packaging plays a positive role in reducing the food losses. When consider packaging and food as a whole system, the overall system's environmental impact can be offset by considering food losses reduction resulting from using active packaging. The LCA calculation shows that the breakeven point can be easily achieved for the case of red meat products of high environmental impact.