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Use of Metallic and Bimetallic Nanostructures as Constituents of Active Bio-Based Films

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Abstract : The use of bio-based packaging materials containing metallic and bimetallic nanostructures is relatively modern technology. In this sense, the food packaging industry has been investigating biological and renewable resources that can replace petroleum-based materials to reduce the environmental impact and, at the same time, including new functionalities using nanotechnology. Therefore, the main objective of the present work consisted of developing bio-based poly-lactic acid (PLA) films with Zinc (Zn) and Zinc-Iron (Zn-Fe) nanostructures deposited by magnetron sputtering. The structural, antimicrobial, and optical properties of the films were evaluated when exposed at 60% and 96% relative humidity (RH). The morphology and elemental analysis of the samples were determined by scanning (transmission) electron microscopy (SEM and STEM), and inductively coupled plasma optical emission spectroscopy (ICP-OES). The structure of the PLA was monitored before and after deposition by Fourier transform infrared spectroscopy (FTIR) analysis, and the antimicrobial and color assays were performed by using the zone of inhibition (ZOI) test and a Minolta colorimeter, respectively. Finally, the films were correlated in terms of the deposit conditions, Zn or Zn-Fe concentrations, and thickness. The results revealed PLA films with different morphologies, compositions, and thicknesses of Zn or Zn-Fe nanostructures. The samples showed a significant antibacterial and antifungal activity against E. coli, P. aeruginosa, P. fluorescens, S. aureus, and A. niger, and considerable changes of color and opacity at 96% RH, especially for the thinner nanostructures (150-250 nm). On the other hand, when the Fe fraction was increased, the lightness of samples increased, as well as their antimicrobial activity when compared to the films with pure Zn. Hence, these findings are relevant to the food packaging field since intelligent and active films with multiple properties can be developed.

Keywords : biopolymers, functional properties, magnetron sputtering, Zn and Zn-Fe nanostructures
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