Application of nanomaterials in bio-composites for packaging application

[1]Fatimatu Bello (Postdoctoral Research Fellow)

[1]Maria Soledad Peresin

[1]Sustainable Bio-based Materials Lab, Auburn University

602 Duncan Dr,

Auburn, AL, USA

fzb0030@auburn.edu

Natural polymer-based films and coatings have seen significant growth in the packaging industry due to their biodegradability and renewability. However, these films show numerous drawbacks in their physicochemical, functional, and mechanical properties. Due to their high hydrophilic nature, these films are highly susceptible to moisture, limiting their application in food packaging. To enhance their properties, strategies such as blending biopolymers or incorporating hydrophobic materials like lipids and lignin have been employed. Lignin improves the UV-barrier, antioxidant, and mechanical properties; however, it exhibits poor dispersibility in polymer matrices due to the irregular morphology and broad molecular weight distributions. Lignin nanoparticles (LNPs), with stable morphology, higher-surface-volume ratio, and better dispersibility, can alleviate the drawbacks of irregular-shaped lignin. Thus, lignin nanoparticles were prepared from Kraft lignin using the solvent exchange method and characterized. Then the effect of lignin and lignin nanoparticles on the physicochemical, mechanical, optical, moisture barrier, and antioxidant properties of different composite films was studied. Optical properties, chemical structural changes, and hydrophobicity were analyzed using UV-visible spectroscopy (UV-Vis), Fourier Transform Infrared Spectroscopy (FTIR), and contact angle measurements. Atomic force microscopy (AFM) and scanning electron microscopy (SEM) were employed to monitor the surface morphology/topography and roughness. The mechanical properties of the films were assessed using an Instron machine. The LNPs were compatible with the polymer matrix, resulting in self-supporting thin films with enhanced tensile strength, antioxidant, water vapor permeability, and UV-barrier properties. The addition of a trace amount of LNPs (1wt%) significantly improved the antioxidant, hydrophobicity, and UV barrier properties without significantly influencing the transparency of the films. Additionally, an improvement in the DPPH radical scavenging activity of composite films was observed, indicating enhanced antioxidant activity compared to films without LNPs. This study presents novel opportunities for LNPs in the development of sustainable packaging materials for diverse applicability including the food industry.