Green Nanotechnology Applied to Textile Functionalization: Development of an Antibacterial Biocoating with Chitosan Nanoparticles

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Abstract

The World Health Organization estimates that millions of people may die from antibiotic-resistant infections by the middle of this century, highlighting the urgent need for sustainable solutions aligned with the One Health approach. In this context, the textile industry offers significant potential for the development of functional materials capable of adding value and meeting emerging health demands. Due to their high surface area and structural versatility, textile substrates are suitable platforms for functionalization that can introduce additional properties such as antimicrobial activity. This study developed an antimicrobial biocoating based on chitosan nanoparticles synthesized through a green route using jabuticaba peel extract (Myrciaria cauliflora). Low-molecular-weight chitosan was dissolved in a 1% (v/v) acetic acid solution, followed by the addition of jabuticaba peel extract in ratios from 1:1 to 1:5 (v/v), under constant stirring (200 rpm) at temperatures between 30 and 50 ∘C. Different pH conditions (3.5–5.5) and reaction times (1–4 h) were evaluated to optimize nanoparticle formation. Nanoparticles were characterized by dynamic light scattering (DLS) to determine the mean hydrodynamic diameter (DH), polydispersity index (PDI), and zeta potential. The biocoating was applied to textile substrates using the Pad Dry Cure method. Nanoparticle fixation on the fibers was evaluated by scanning electron microscopy (SEM), while antimicrobial activity was assessed for durability (AATCC 61) and performance against Staphylococcus aureus and Klebsiella pneumoniae according to AATCC 147. DLS results indicated nanoscale particles (< 100 nm) with a PDI of approximately 30%, pH of 5.5, and reduced surface tension (60.4 mN/m), indicating good applicability of the suspension to textile substrates. The nanoparticles showed dense structures and irregular surfaces, attributed to interactions between chitosan and phenolic compounds and anthocyanins from the jabuticaba extract. SEM images confirmed nanoparticle deposition on fiber surfaces, and antimicrobial tests demonstrated inhibition of bacterial growth by direct contact. The developed system represents a scalable and environmentally responsible alternative for antimicrobial textile finishing.

Keywords: Chitosan nanoparticles, Green synthesis, Antimicrobial textiles, Biocoating.

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