

Title : Finishing of Multifunctional Cotton Fabric using Tea Tree Oil-Loaded Urea-Formaldehyde Microcapsules Incorporated with Zinc Oxide Nanoparticles.

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ABSTRACT

This research investigates the development of a multifunctional finishing process for cotton fabrics utilizing tea tree oil-loaded urea-formaldehyde microcapsules in combination with zinc oxide nanoparticles (ZnO NPs). The microcapsules were synthesized via in-situ polymerization, where the influence of stirring speed (250–1,250 rpm) on microcapsule formation was systematically evaluated. Morphological characterization using Scanning Electron Microscopy (SEM) and particle size distribution analysis identified 500 rpm as the optimal speed, yielding spherical microcapsules with smooth surfaces and a maximum encapsulation efficiency of 30.57%. The optimized microcapsules were subsequently incorporated with ZnO NPs and applied onto cotton fabrics using a padding–drying–curing method with an acrylic binder. The treated fabrics exhibited enhanced multifunctional performance. Improved surface hydrophobicity was achieved, with water contact angles ranging from 102.36° to 136.48°, confirming effective water repellency. Moreover, the synergistic interaction between the microcapsules and ZnO NPs significantly enhanced UV protection, resulting in a 35.5% improvement compared to untreated fabrics. Photocatalytic self-cleaning performance was also demonstrated through the degradation of organic coffee stains under D65 standard illuminant irradiation. These findings suggest that the integration of microencapsulation and ZnO NPs offers a high-potential strategy for advancing multifunctional textile finishing and functional coatings.

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