Sustainable Innovations in Textile Functionalization and Coating: From Sustainable Finishing and Bio-Based Dyes to Circular Economy

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Abstract

Current research in the field of textile functionalization and coating combines material, chemical, and process engineering approaches to develop sustainable and high-performance textile systems. Key areas of focus include the development of resource-efficient sizing agents and sustainable coating materials, the use of PFAS-free alternatives as environmentally friendly solutions for functional coatings, and the application of bio-based and natural dyes for the coloration of textile materials. Furthermore, emphasis is placed on enhancing the functionality of textile structures, for example, through metallized and electrically conductive yarn coatings, which open up new fields of application.
Another major research focus is the circular economy and recycling. This involves analyzing material combinations, coatings, and finishes in terms of their recyclability, separability, and reusability, while integrating circular economy principles directly into material and process development. The goal is to translate these innovative approaches into reproducible and scalable industrial processes through targeted procedural and process development.
These activities are supported by comprehensive technical infrastructure, including multifunctional coating and plasma systems, modular pilot-scale equipment for coating textile materials, dyeing units for natural dyes, as well as extensive nano and mikro analytical methods for the characterization of dyes, coatings, and textile materials. The overarching objective of these research activities is to develop resource-efficient, low-pollutant, functional, and circular solutions that can sustainably shape future applications in textile finishing and coating.

Keywords: Natural dyes, PFAS, free coatings, electrically conductive yarn coatings, recycling/circular economy, process development

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