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Evaluating natural organic acids for antibacterial bio-based textile finishing

N. Bio-based high-performance textile coatings

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Abstract

Natural organic acids (i.e., caffeic acid, trans-ferulic acid, gallic acid, lactic acid, L-ascorbic acid and tartaric acid) have high potential as eco-friendly, non-toxic and sustainable antibacterial textile finishes, particularly for cotton. They inhibit bacteria by lowering pH (as the skin) and by penetrating cell membranes, often achieving over 95% reduction against bacteria such as Staphylococcus aureus and Escherichia coli.

Natural organic acids are biodegradable alternatives to synthetic antibacterial agents, aligning with consumer demand for sustainable, skin-friendly medical and daily-use textiles. A key area of research is improving the stability of these acids to fabrics to ensure durability against washing and dry cleaning. For this reason, we have investigated the combination with bio-based polymer matrices.

Among the systems evaluated, specific combinations of organic acids and bio-based polymer matrices significantly reduced bacterial growth (>85%) while preserving the mechanical strength and tactile quality of fabrics. Spectroscopic findings indicate that hydrogen bonding and partial esterification between hydroxyl and carboxylic groups facilitate adhesion of the coating to the cotton surface. These chemical interactions are crucial to the durability and performance of functional finishes.

Among the six natural organic acids tested, lactic acid, L-ascorbic acid, and tartaric acid clearly stood out. In solution, all three achieved about 99–100% bacterial reduction against both bacteria. When applied to cotton solutions containing 10% w/v acid, the fabrics still showed >95% bacterial reduction. Reducing the acid concentration to 5% w/v resulted in only a modest loss of activity: lactic acid and

tartaric acid still achieved >99% bacterial reduction, L-ascorbic acid remained effective, though slightly less consistent. This shows that efficient antibacterial textiles can be produced with minimal chemical input, improving cost-effectiveness and sustainability.

The use of tartaric acid, in particular, showed the most promising results in terms of efficacy and duration of action after cleaning, suggesting a feasible pathway for developing antibacterial textiles suitable for healthcare, hygiene, and sportswear applications. These results could expand the applicability of bio-based coatings beyond disposable or single-use products.

The outcomes suggest that water-based, bio-derived formulations are a viable strategy for producing eco-friendly antimicrobial textiles that meet industry needs for renewable, cost-effective, non-toxic, and formaldehyde-free solutions.