Durable Bio-Based Multifunctional Coatings for Cotton and NyCo Fabrics

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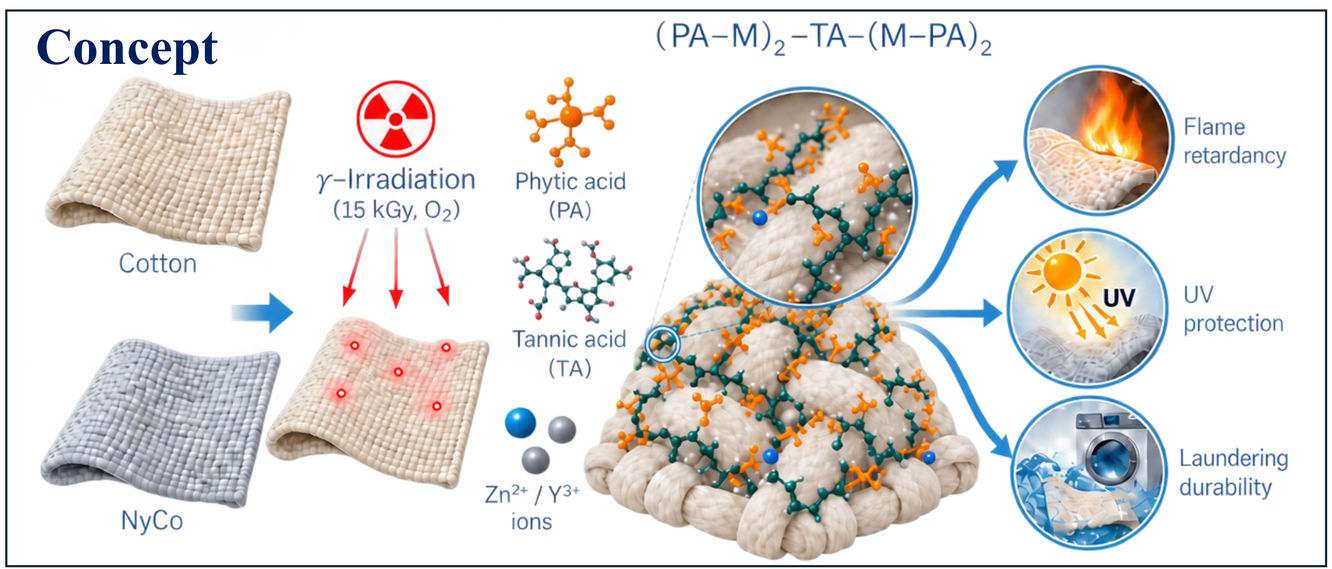
Background

The development of multifunctional protective textiles requires coating systems that combine effective flame retardancy and UV protection with long-term durability.

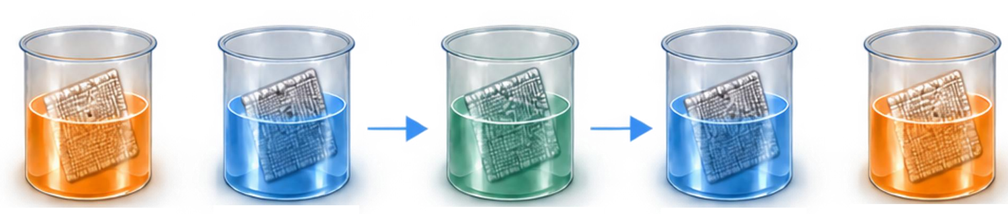
Bio-based compounds such as phytic acid (PA) and tannic acid (TA) offer promising alternatives to conventional synthetic additives due to their phosphorus-rich and polyphenolic structures, respectively. However, maintaining protective performance after repeated laundering remains a major challenge.

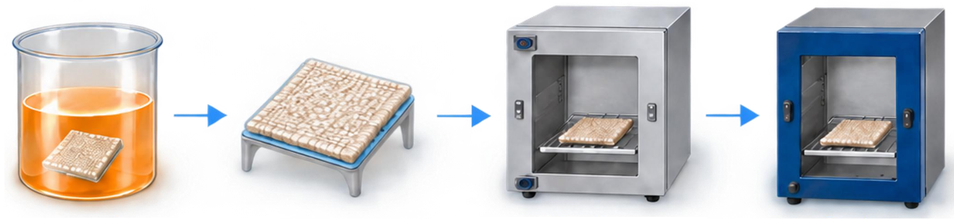
In this study, cotton and nylon/cotton blend (NyCo) fabrics were functionalised with multilayer PA-TA coatings incorporating Zn^{2+} and Y^{3+} ions to enhance flame retardancy, UV protection, and coating durability.

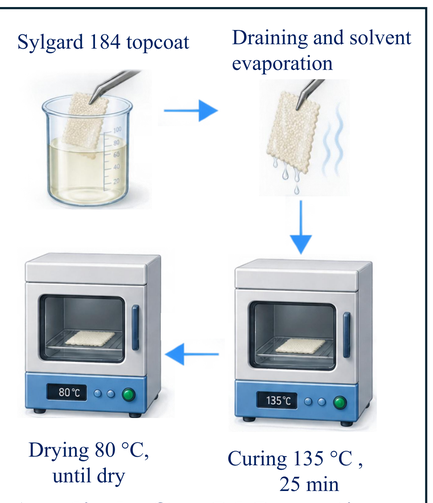
Concept



Experimental methodology







Characterization



SEM-EDS



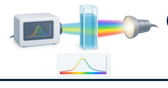
FLAME RETARDANCY



UV PROTECTION



WASHING DURABILITY

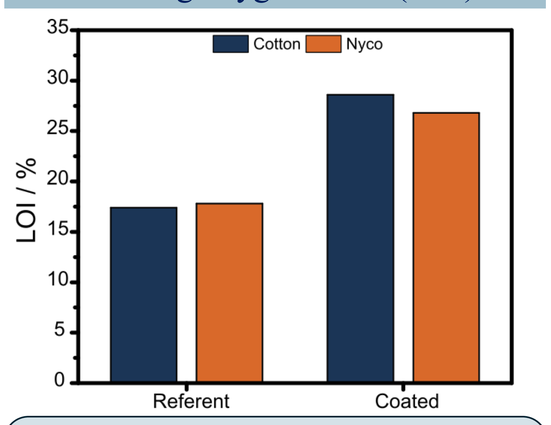


COLORIMETRY ANALYSIS

Results

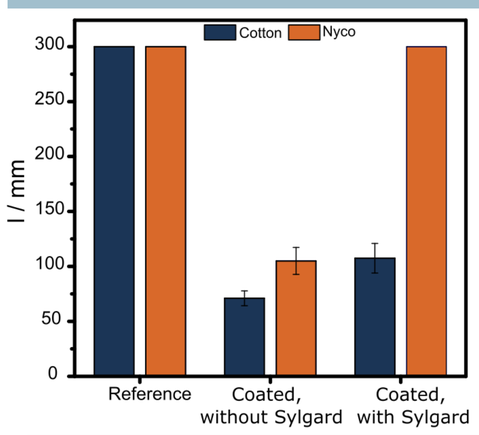
Flame retardancy

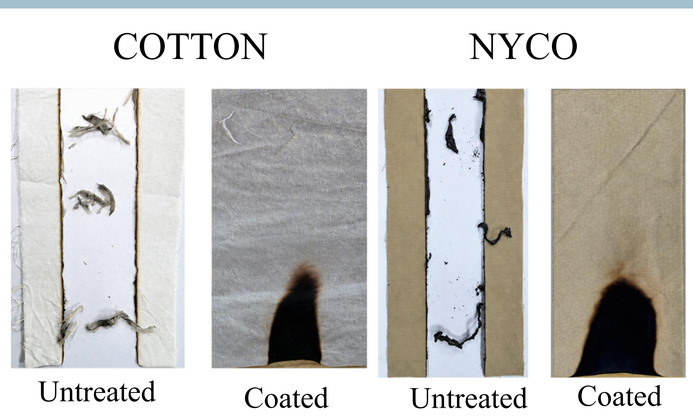
Limiting oxygen index (LOI)



The coatings increased LOI from 17.4 to 28.6% for cotton and from 17.8 to 26.8% for NyCo, indicating enhanced flame retardancy.

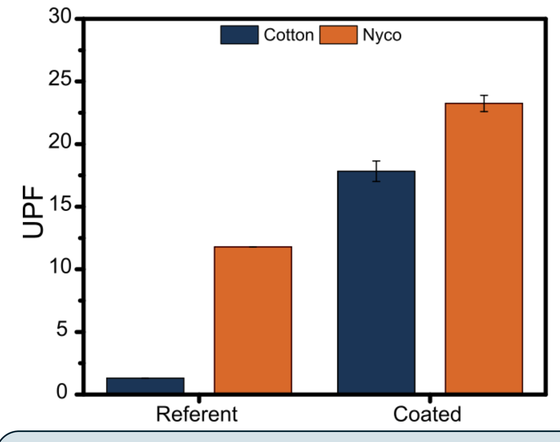
Vertical flame test





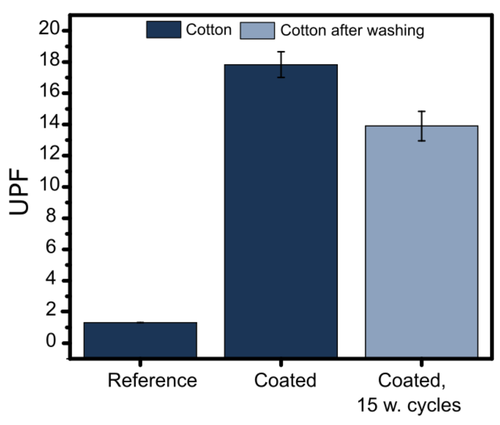
Without Sylgard 184, char length decreased from 300 mm to 71 mm for cotton and 105 mm for NyCo. Sylgard 184 improved cotton's washing durability but increased its char length to 107.5 mm, while Sylgard-treated NyCo textiles burned completely.

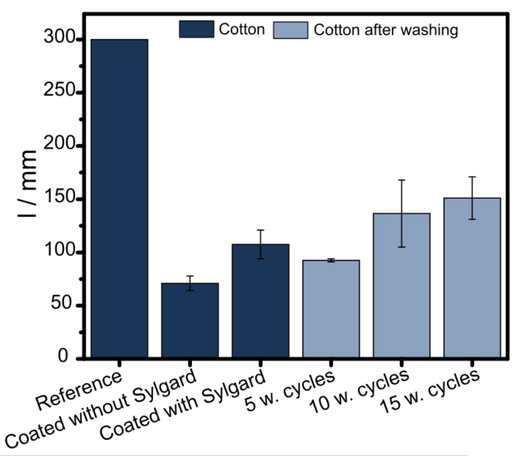
UV protection



The coatings increased UPF from 1.32 to 17.83 for cotton and from 11.78 to 23.25 for NyCo, improving UV protection in both fabrics.

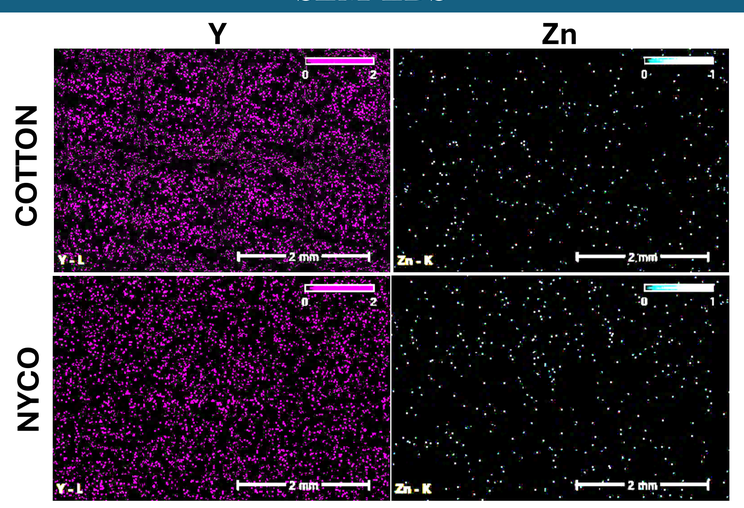
Washing durability





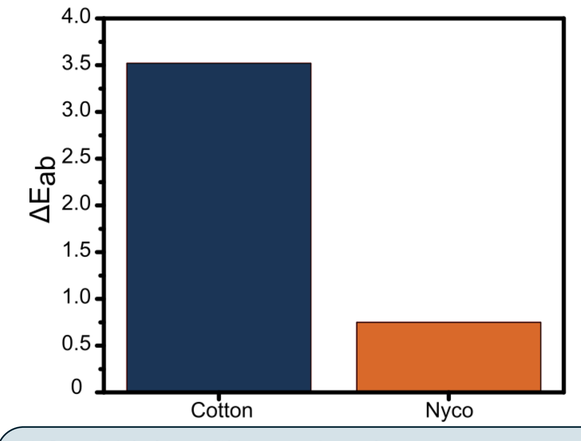
After 15 washing cycles, coated cotton retained higher UPF (1.32 →13.90) and shorter char length (151 vs. 300 mm) than untreated cotton, demonstrating retained protective performance.

SEM-EDS



SEM-EDS elemental mapping confirmed the presence of Y and Zn on the surfaces of coated cotton and NyCo fabrics.

Colorimetric analysis



After 24 h in HCl at pH 2 and room temperature, ΔEab was 3.52 for cotton and 0.75 for NyCo, indicating greater colour stability of NyCo under the tested acidic conditions.

Conclusion

- PA/TA - metal-ion coatings improved flame retardancy and UV protection of both cotton and NyCo fabrics.
- Sylgard 184 improved cotton's washing durability, with enhanced protective performance retained after 15 washing cycles.
- NyCo showed a smaller colour change than cotton after acidic exposure, indicating greater colour stability under the tested conditions.



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