

# SUMMARY

## Safe Flame Retardants from Nature.

**Cotton, viscose, and linen are widely used textiles, but they can burn easily and contribute to the spread of fire. Flame retardants can improve their fire performance and concerns about the health and environmental effects of some existing chemicals encourage the search for alternatives. In this project, we investigated naturally occurring compounds as potential flame retardants for these fabrics. The results showed that creatinine, particularly when combined with phosphoric acid, could considerably reduce heat release and promote char formation. However, water resistance remained a challenge.**

### Purpose and objectives

We aimed to explore a route towards safer flame-retardant treatments using molecules found in nature, including compounds that could potentially be recovered from waste streams. We wanted to understand how the choice of compound, solution pH, and fabric affected the treatment performance. Another objective was to investigate whether combining nitrogen-containing molecules with phosphate groups could improve fire protection, and whether copper ions could help the treatment remain on the fabric after water exposure.

### Methods and implementation

We screened several compounds, including creatinine, sodium succinate, hippuric acid, and L-glutamine. Cotton, viscose, and linen were dipped in aqueous solutions at different pH values and dried. Simple flame tests helped us identify treatments that prevented ignition or allowed the flame to extinguish. The selected samples were then examined using microscale combustion calorimetry to measure heat release and thermogravimetric analysis to study decomposition and char formation. The most promising formulation was tested by cone calorimetry at heat fluxes of 35 and 50 kW/m². Selected treatments were also evaluated after brief immersion in water to assess their resistance to leaching.

### Results

Creatinine gave the most promising overall performance, while sodium succinate also improved flame resistance. Combining creatinine with phosphoric acid produced strong reductions in heat release across all three fabrics. In microscale combustion tests, the combined treatment reduced peak heat release by 85-93% depending on fabric type. Thermal analysis showed that treated fabrics generally began to decompose earlier but retained more material at higher temperatures. This behavior indicates that the treatments encouraged char formation, reducing the material available for combustion. None of the fabrics treated with the selected formulation ignited during cone calorimetry at either heat flux. They formed char and showed substantially lower peak heat release, although considerable smoke was produced. Copper ions provided no additional improvement in flame resistance and water exposure reduced the protective effect, showing that stronger attachment to cellulose is needed. Further work should therefore focus on improving water durability and optimizing treatment conditions before practical application.

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