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Perspective: Re-Evaluating Wood Protections - Fungal Resistance of MCA-Treated Cross-Laminated Timber

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A B S T R A C T

Cross-laminated timber (CLT) is increasingly used in modern construction due to its environmental benefits and structural properties. However, its biological durability remains a concern, particularly its resistance to fungal degradation in service conditions. This study evaluates the effectiveness of Micronized Copper Azole (MCA) as a wood preservative by developing a modified soil block test aligned with American Wood Protection Association (AWPA) standards. Southern Yellow Pine (SYP) CLT blocks, both treated and untreated, were exposed to three brown-rot fungi (Postia placenta, Coniophora puteana, and Neolentinus lepideus) and one white-rot fungus (Pleurotus ostreatus). Preliminary results suggest that MCA-treated blocks show significant resistance to fungal-induced mass loss. We argue for the standardization of a modified testing method to better simulate in-service performance and encourage the use of MCA in long-term timber protection strategies.

Keywords: Cross-laminated timber, MCA, fungal resistance, wood preservation, brown-rot, white-rot, AWPA E-20, Southern Yellow Pine

1. INTRODUCTION

The resurgence of wood in sustainable architecture has brought cross-laminated timber (CLT) into the spotlight. CLT, composed of layers of solid-sawn lumber glued at perpendicular angles, offers advantages in strength, weight reduction, and carbon sequestration. However, its vulnerability to fungal decay, especially in high-humidity environments, limits its wider adoption.

Fungal degradation of timber products poses one of the most serious threats to long-term structural performance, especially in modern engineered wood products like CLT that are intended for large-scale construction. Unlike traditional lumber, CLT's laminated structure introduces unique challenges in preservative treatment, penetration, and uniformity. When exposed to the right conditions, elevated moisture, oxygen, and biological activity, fungal organisms rapidly colonize and decompose cellulose and hemicellulose, resulting in strength loss and compromised durability.

Brown-rot fungi such as Postia placenta and Coniophora puteana, along with white-rot fungi like Pleurotus ostreatus, degrade wood through highly evolved genetic and proteomic mechanisms. These organisms produce an arsenal of extracellular enzymes, encoded by specific fungal genes, that catalyze lignin breakdown and cellulose hydrolysis. Understanding these pathways not only informs wood protection strategies but also aligns this research with broader efforts in fungal genomics and protein science.

From a molecular perspective, these fungi employ genes that express oxidoreductases (such as laccases, peroxidases, and glycoside hydrolases) to facilitate wood decomposition. The expression of these enzymes is tightly regulated by environmental cues and stress-response genes. Insights from this work could be expanded through transcriptomic and proteomic analysis of fungal activity on treated vs. untreated substrates. Additionally, studying how preservatives like MCA suppress gene expression in these fungi could provide a molecular-level basis for antifungal resistance and material longevity.

Historically, standardized tests such as the AWPA E-10 and E-20 protocols have guided the evaluation of preservative efficacy. However, these protocols often fail to capture the layered behavior and bonding nuances of CLT. With the emergence of Micronized Copper Azole (MCA) as a new-generation wood preservative, a critical question arises: how effective is MCA in protecting CLT under realistic service conditions, and what adaptations to testing methodologies are needed to measure that effectiveness? This study seeks to close that gap by designing a modified soil block test tailored for CLT, thereby evaluating MCA's efficacy more holistically.

2. Experimental Rationale and Methods

This perspective article outlines the experimental procedures carried out by the researchers as follows:

2.1 CLT Block Preparation

CLT blocks made from Southern Yellow Pine were categorized into treated (MCA) and untreated groups. Dimensions adhered to modified AWPA E-20 protocol specifications, with adjusted sample sizes and soil volumes.

2.2 Fungal Strains and Soil Preparation

Four fungi were used:

- Postia placenta, Coniophora puteana, Neolentinus lepideus (brown-rot)
- Pleurotus ostreatus (white-rot)

Soil containers were filled with high water-retention media. Each fungus was inoculated into its designated container and incubated for two weeks at 29°C to ensure robust fungal colonization.

2.3 Exposure and Incubation Protocol

Both treated and untreated CLT blocks were placed into the inoculated soil containers. The experimental period lasted 16 weeks under constant 29°C conditions, simulating in-service temperature for fungal activity.

2.4 Weight Loss Measurement

After exposure, blocks were dried and weighed to calculate mass loss as an indicator of fungal degradation.

3. Results: Resistance Through Preservation

The results shown by the analyzed study is shown below:

Preliminary expectations were largely met:

- Untreated CLT blocks: exhibited significant fungal damage, with an average of 40% mass loss.
- MCA-treated blocks: retained their mass with minimal observable decay, confirming MCA's antifungal performance.

This supports the hypothesis that MCA significantly impedes both brown- and white-rot fungi, preserving CLT's structural integrity in hostile conditions.

4. Call to action: Toward a Modified Testing Paradigm

Existing AWPA testing standards often do not reflect the dimensions, adhesive interfaces, or structural configurations of CLT. Our modified soil block test incorporated larger specimen dimensions and soil volume to accommodate the layered nature of CLT. Based on the outcomes observed, we propose further optimization of:

- Soil moisture saturation ratios
- Fungal inoculum densities
- Exposure durations for real-world simulation

5. Conclusion: A Call for Modernized Protocol

Micronized Copper Azole shows strong potential as a fungal deterrent for CLT applications. More importantly, this work illustrates the importance of adapting traditional test protocols to accommodate emerging wood technologies. By refining soil block testing parameters, we can better forecast material performance and enable safer, more durable timber construction.

Future interdisciplinary research could incorporate molecular tools such as qPCR, proteomics, or transcriptomics to measure fungal gene expression during wood colonization. This would link material durability studies to broader inquiries in fungal genetics, enzymatic regulation, and microbial ecology.

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