Microemulsions made from pulp and paper side-streams as a potential alternative to conventional wood impregnation. Exploring complex liquid systems with turpentine.

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The Nordic forest sector produces considerable quantities of side-streams including sulphate turpentine and birch bark. Turpentine is currently sold for external refining, while betulin-rich birch bark is typically incinerated for low-value energy recovery. Developing high-value internal applications for these streams is essential for enhancing resource efficiency and supporting a circular bioeconomy. This study investigates the potential of turpentine-based microemulsions for sustainable wood preservation.

Microemulsions – thermodynamically stable, isotropic liquid systems – facilitate the solubilisation of hydrophobic compounds and their controlled delivery into porous substrates. Characterised by low viscosity and ultralow surface tension, these systems enable effective wood impregnation at ambient conditions, potentially eliminating the need for energy-intensive vacuum or high-pressure treatments [1] [2] [3]. While turpentine has traditionally served as a solvent with documented antiparasitic, disinfectant, antifungal, and insect-repellent properties [4], its high volatility limits long-term efficacy. Although previous research confirmed turpentine's fungicidal performance against wood-decaying fungi (e.g., Coniophora puteana) via surface painting [5] [6], this study explores its utility as the oil phase in microemulsion systems to achieve deeper penetration.

To maximize the microemulsion fraction, salinity, surfactant concentrations, water-to-oil ratios (WOR), and surfactant-to-alcohol ratios (SAR) were systematically optimised. To address turpentine's volatility, betulin – valued for its antibacterial, antifungal, and antiviral properties [7] was selected as a reinforcing agent. Although raw betulin exhibited poor dispersibility, its hydrophobic derivative, betulin diacetate, significantly improved stability.

To evaluate impregnation depth and distribution, a novel tracing approach was explored. A complex formed between a chelating surfactant and copper ions was incorporated into two chosen microemulsions, enabling detection by energy-dispersive X-ray spectroscopy (EDS). Impregnated wood samples and freeze-dried microemulsions were analysed using scanning electron microscopy (SEM) coupled with EDS mapping. The results demonstrate the feasibility of turpentine-based microemulsions as carriers for active compounds in sustainable wood preservation.

Keywords:
Microemulsions, wood impregnation, anti-fungal, anti-microbial, turpentine, wood preservation

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