Corepan Bois
Consortium de recherche sur les panneaux composites à base de bois

UNIVERSITÉ LAVAL

Bioadhesives from Forest to Future: Reducing Formaldehyde with Tannin-Based Innovations

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Introduction

The rising demand for sustainable materials, driven by regulations to mitigate the environmental impact of petrochemical products, has spurred the development of bio-based adhesives as alternatives to traditional petrochemical-based products.

Formaldehyde-based adhesives, commonly used in wood products, raise health and environmental concerns due to formaldehyde emissions, a recognized carcinogen.

Tannins, natural polyphenolic compounds found in tree barks, offer a promising solution. They are abundant, renewable, and possess excellent bonding properties with low toxicity, making them ideal for eco-friendly adhesive development (1)

This research focuses on extracting tannins from Boreal forest species—black spruce, white spruce, and jack pine—to formulate formaldehyde-free adhesives. By enhancing tannin extraction techniques and optimizing adhesive formulations, the project aims to reduce reliance on harmful chemicals and contribute to a more sustainable, greener future.

Objectives

This project aims to develop bio-based adhesives using tannins extracted from North American softwoods, focusing on optimizing extraction methods for high-purity tannins. It seeks to reduce dependence on harmful chemicals and enhance industrial sustainability. The specific objectives are:

1- Optimize Tannin Extraction: Enhance the yield and purity of tannins through improved extraction methods.

2- Develop Formaldehyde-Free Adhesives: Formulate and characterize tannin-based adhesives using alternative crosslinkers.

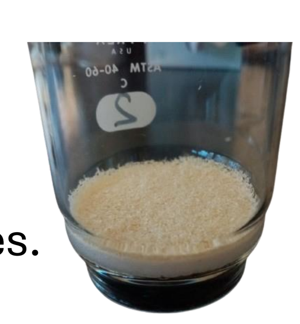
3- Characterize Composite Panels: Prepare and test wood panels using the most effective bioadhesive formulations from Objective 2.

Methodology

Bark Sample Collection and Preparation

Bark samples from black spruce (*Picea mariana*), white spruce (*Picea glauca*), and jack pine (*Pinus banksiana*) are sourced from boreal Quebec forests and local sawmills. The samples are dried, milled, and sieved to particle sizes of 40 and 60 mesh.

Bark Composition Characterization



The samples are analyzed for moisture, ash, extractives, lignin, hemicelluloses, and cellulose using standard procedures.

Tannin Extraction

Tannin extraction is performed using hot water and organic solvents, with a preference for hot water to enhance yield and quality. The extracted tannins are evaluated via UV-Vis spectroscopy, FTIR spectroscopy, HPLC, Pyrolysis-GC/MS, and Stiasny index to assess reactivity.

Adhesive Formulation

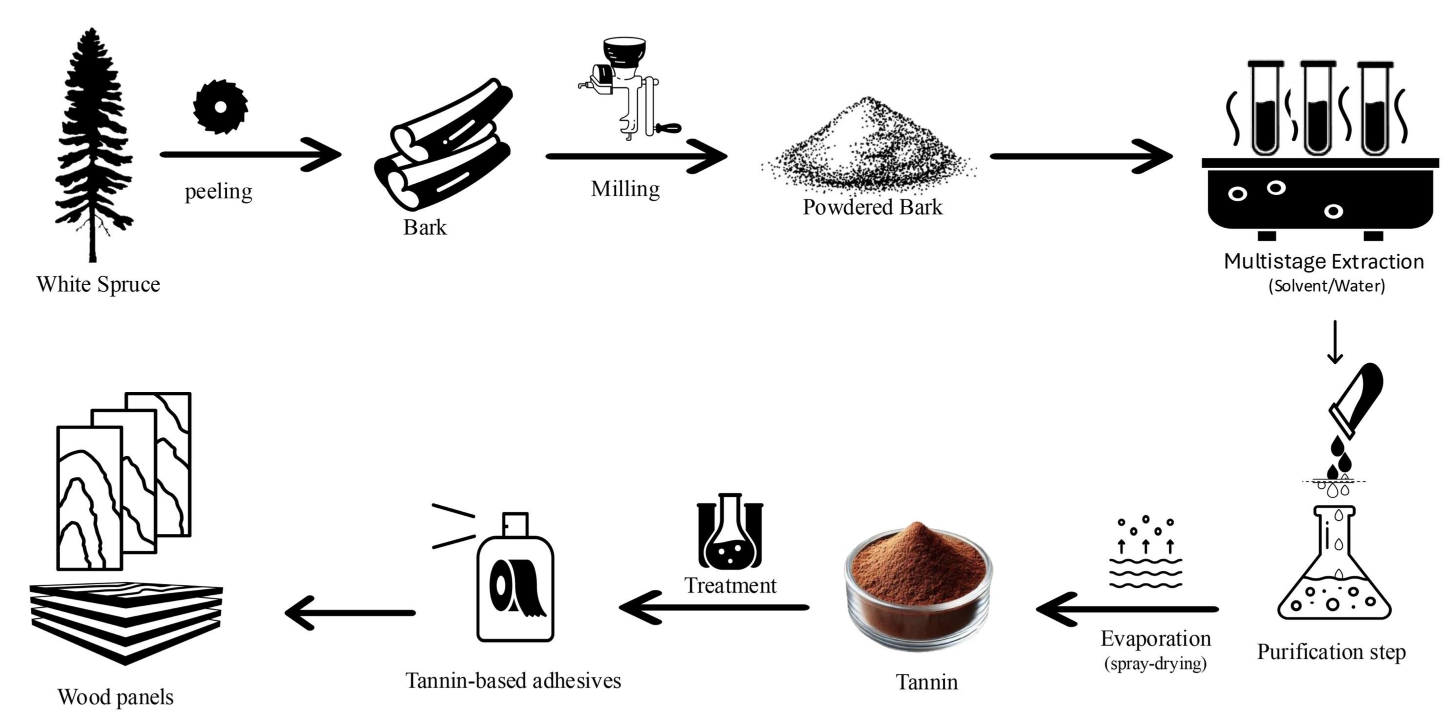
Tannin-based adhesives are prepared with various low-toxicity crosslinking agents. Physical properties are tested, including viscosity (ISO 2555), pot life (ISO 10364), gel time (ASTM D2471-08), water resistance, and mechanical properties (ASTM D905, D1037, D7998).

Preparation and Testing of Wood Panels

The adhesives are applied in composite panel preparation that meets industrial standards. Physical and mechanical properties such as thickness swelling, water absorption, flexural strength, and internal bond strength are assessed according to ASTM D1037. Formaldehyde and VOC emissions are measured using the small chamber test (ASTM D6007) and GC-MS.

Optimization

Statistical analysis and modeling optimize extraction methods and adhesive formulations to improve economic and environmental performance.



Results and Conclusion

Extractive percentage results across the three species; 56% for Jack Pine, 59% for Black Spruce, and 62% for White Spruce; highlight their potential for sustainable tannin production. It is important to note that these percentages reflect the total extractives, which include tannins and other compounds. Given the 15% extractive yield from white spruce in hot water extraction and considering the advantages of this method for tannin extraction, white spruce appears to offer more promising results compared to the other two species.

	Species		
Method	Jack Pine	Black Spruce	White Spruce
Ethanol-Toluene Ext	10.6 ±0.1	14.3 ±0.9	17.9 ±0.2
Hot water Ext	7.7 ±0.1	8.7 ±0.7	15 ±0.5
NaOH (1 %) Ext	38 ±0.5	36.4 ±0.8	29 ±0.1
Total	56.4 ±0.7	59.5 ±2.4	62 ±0.8

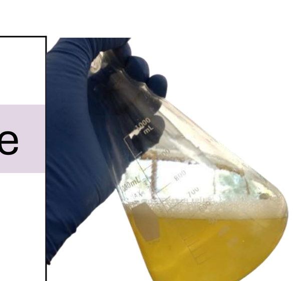


Table 1. Extraction Yields of Extractives from Jack Pine, Black Spruce, and White Spruce Bark (% of Oven-Dried Mass)

The increasing trend of tannin utilization over the past decades underscores the industry's shift toward sustainable materials. With continued advancements, **tannin-based adhesives** have the potential to **transform the adhesive market**, offering a greener alternative that supports **climate action** and reduces **environmental impact**.

This project highlights the growing importance of tannin-based adhesives as a sustainable alternative to conventional adhesives containing formaldehyde. We aim to produce high-purity tannins from North American softwoods by optimizing extraction methods. These innovations promise to **reduce dependence on harmful chemicals** and **improve industrial durability**, aligning with global environmental goals.

References:
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