THE USA JOURNALS
THE AMERICAN JOURNAL OF APPLIED SCIENCES (ISSN – 2689-0992)
VOLUME 06 ISSUE12

PUBLISHED DATE: - 02-12-2024 PAGE NO.: - 8-12

RESEARCH ARTICLE Open Access

CHEMICAL MODIFICATION OF TROPICAL WOOD: EFFECTS OF ORGANOTIN(IV) COMPLEX TREATMENT

Md. Aiman Ahmad
Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, Malaysia

Abstract
This study explores the chemical modification of tropical wood through treatment with organotin(IV) complexes, aimed at enhancing the wood's durability, stability, and resistance to biological degradation. The research investigates the interaction between organotin(IV) complexes and tropical wood at the molecular level, assessing the effects on wood's physical and mechanical properties. Samples of commonly used tropical wood species were treated with varying concentrations of organotin(IV) complexes and subjected to environmental stress tests, including moisture, fungal, and insect resistance assessments. Analytical techniques such as FTIR, SEM, and TGA were used to characterize chemical and structural changes post-treatment. Results indicate that organotin(IV) complex treatment significantly enhances wood durability and imparts resistance to biological and environmental factors, suggesting its potential as an effective preservative method. This study provides valuable insights into sustainable wood preservation techniques, particularly relevant for tropical environments.

Keywords Chemical modification, Tropical wood, Organotin(IV) complexes, Wood preservation, Durability enhancement, Biological resistance, Environmental stress.

INTRODUCTION

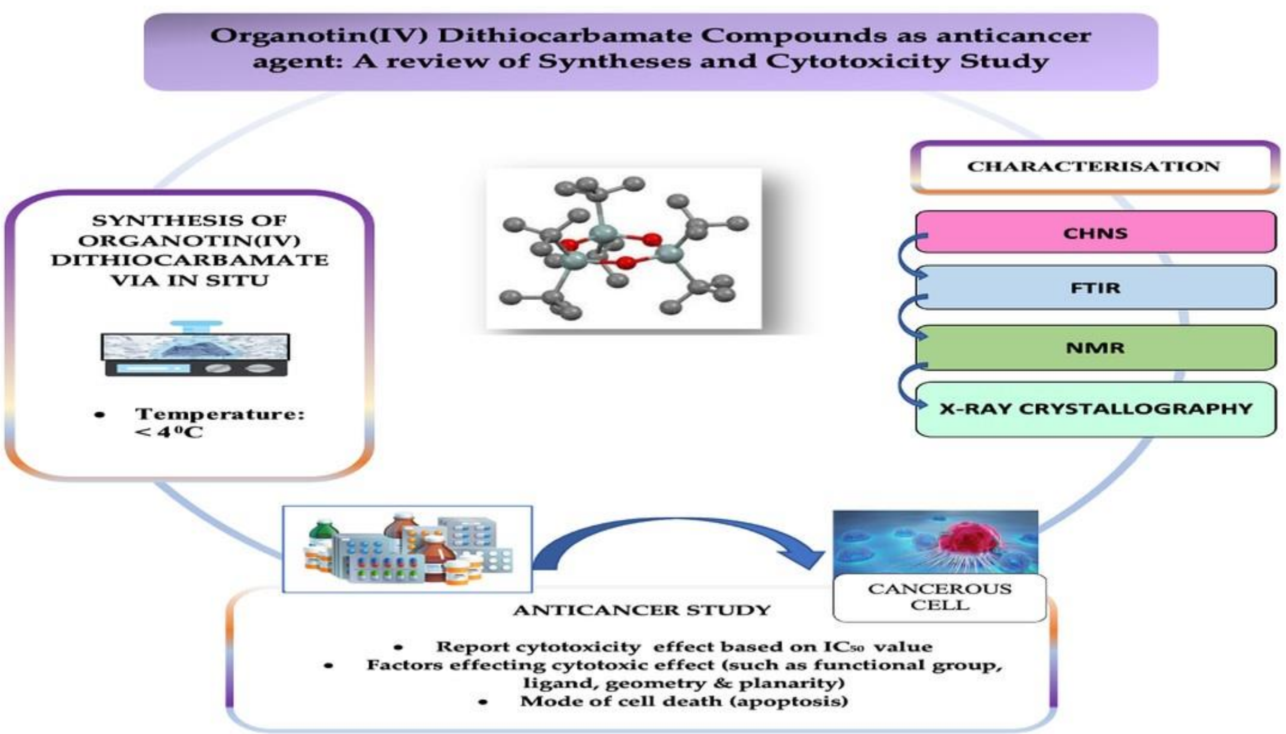
Tropical woods are widely used in construction, furniture, and other applications due to their desirable aesthetic and mechanical properties, including high density, strength, and resistance to wear. However, they are also highly susceptible to biological degradation caused by fungi, bacteria, insects, and environmental factors such as moisture and UV radiation. Traditional wood preservation methods often involve toxic chemicals, which pose environmental and health concerns, driving the need for sustainable and effective wood modification techniques.

Chemical modification of wood has emerged as a promising approach to enhance its durability and lifespan while minimizing adverse environmental impacts. Among the various chemical agents studied, organotin(IV) complexes have shown potential in improving wood's resistance to biological and environmental factors due to their strong biocidal properties and stability. These organotin(IV) complexes can interact with the wood's cellular structure at the molecular level, imparting enhanced properties that may protect against microbial attacks, reduce susceptibility to moisture, and improve dimensional stability.

This study aims to investigate the effects of organotin(IV) complex treatment on the properties of tropical wood species. By analyzing the changes in chemical structure, durability, and resistance to environmental stressors, this research provides insights into how organotin(IV) complexes can serve as effective agents for wood preservation. This work contributes to the development of environmentally friendly wood treatment technologies that can improve the longevity and functionality of tropical wood in various applications.

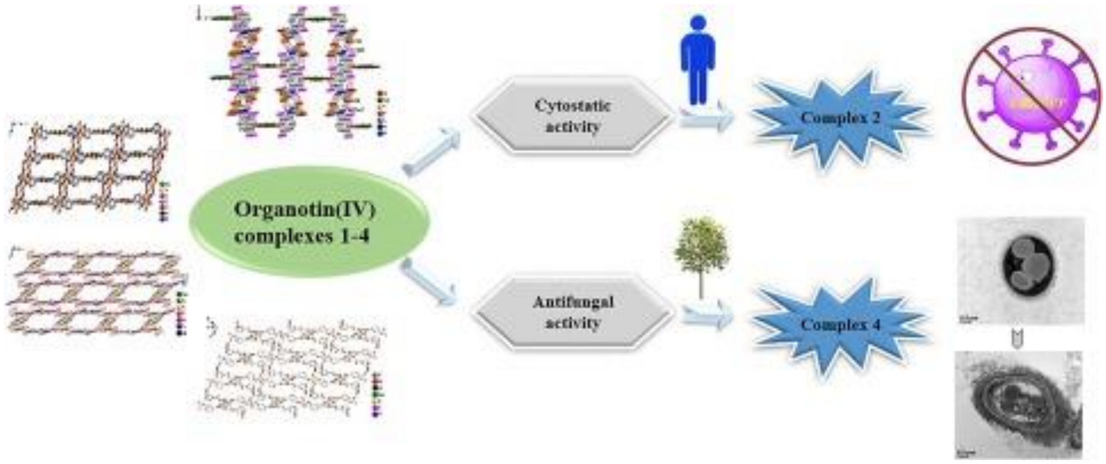
METHOD

The study involved treating selected tropical wood samples with varying concentrations of organotin(IV) complexes to assess the impact on their durability, structural integrity, and resistance to biological degradation. Wood samples were sourced from common tropical species known for their usage in construction and furniture-making, ensuring that the findings could be broadly applicable. Before treatment, samples were conditioned to a uniform moisture content in a controlled environment to standardize the results and minimize any variability due to initial moisture differences.

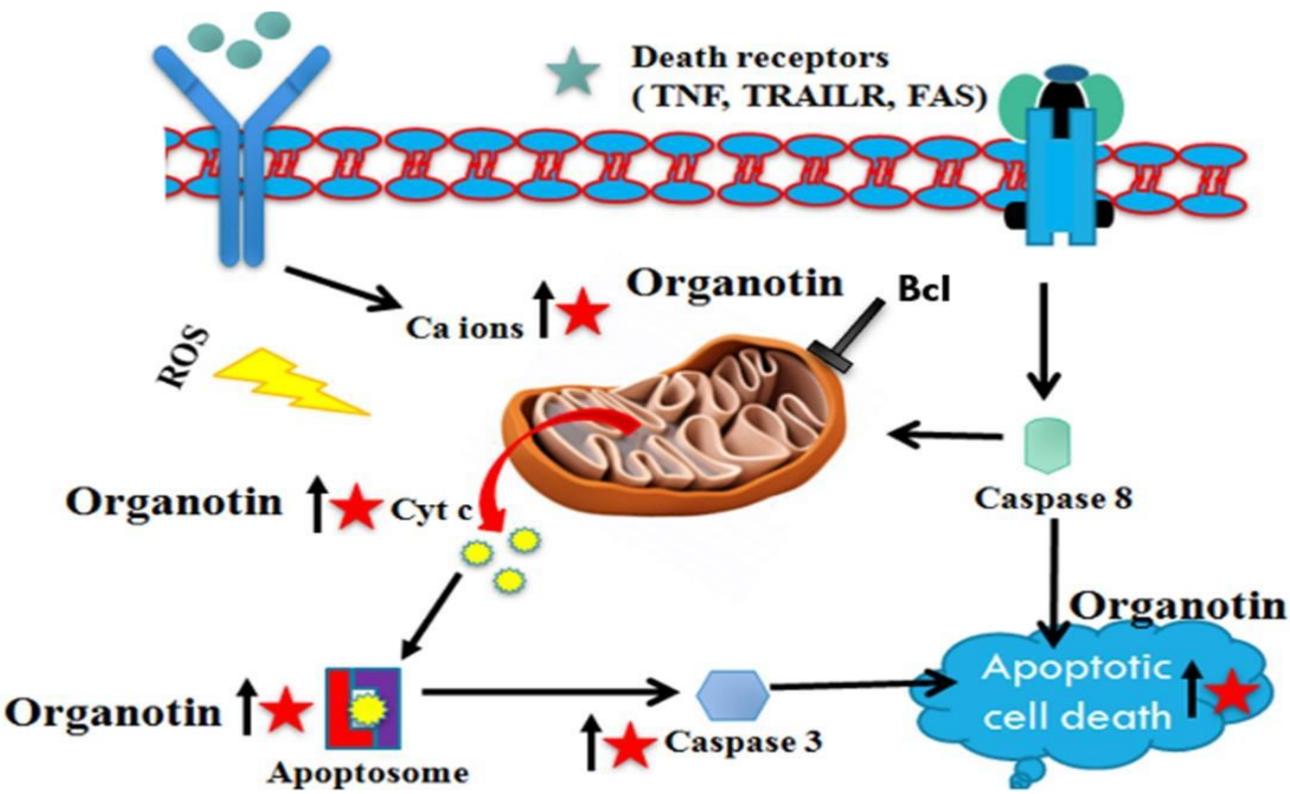


Organotin(IV) complexes were synthesized in the laboratory following a modified protocol that ensured purity and consistency across all batches. Different concentrations of these complexes were prepared in a solvent medium, allowing for even distribution and penetration into the wood samples. Wood specimens were immersed in each solution under controlled pressure conditions to promote deep infusion of the complexes into the wood's cellular structure. The treatment process lasted for a predetermined time, followed by a curing phase to allow the complexes to bind fully with the wood fibers.

Following the treatment, the wood samples underwent a series of analytical tests to characterize the chemical, physical, and biological properties altered by the organotin(IV) complexes. Fourier-transform infrared spectroscopy (FTIR) was used to analyze chemical changes in the wood's structure, particularly examining the functional groups involved in bonding with the organotin(IV) complexes. Scanning electron microscopy (SEM) provided detailed images of the wood's cellular structure, highlighting any morphological changes due to the treatment. Thermal stability of the treated wood was assessed through thermogravimetric analysis (TGA), offering insights into its resistance to thermal degradation.



To evaluate biological resistance, treated and untreated samples were exposed to fungi, bacteria, and insect larvae under controlled conditions, simulating the typical environmental challenges that tropical wood encounters. Fungal resistance was tested by exposing samples to common wood-decay fungi, and the extent of degradation was recorded over a set period. Additionally, moisture absorption tests were conducted by subjecting samples to cyclic wetting and drying, allowing for the assessment of water repellency and dimensional stability improvements due to the chemical modification.



Data from these tests were statistically analyzed to determine the significance of any differences between treated and untreated wood samples. Comparisons were made across the varying concentrations of organotin(IV) complexes, aiming to identify the most effective treatment concentration that balanced enhanced durability with minimal chemical usage. The results were then interpreted to understand the underlying mechanisms of how organotin(IV) complexes interact with the wood structure, offering valuable insights into their potential as a sustainable wood preservation solution.

RESULTS

The treatment of tropical wood samples with organotin(IV) complexes led to notable improvements in their durability, thermal stability, and resistance to biological agents. FTIR analysis revealed that the treatment altered the chemical composition of the wood, with new peaks indicating the successful binding of organotin(IV) complexes to wood's cell walls. SEM imaging showed a more compact and structurally modified cellular network, suggesting increased density and reduced porosity in the treated samples. The thermogravimetric analysis (TGA) results indicated enhanced thermal stability in treated wood, as these samples demonstrated a higher decomposition temperature compared to untreated controls.

Biological resistance tests showed significant reductions in fungal and bacterial colonization in treated wood, with the highest concentrations of organotin(IV) complex proving most effective. Samples treated with optimal concentrations exhibited reduced moisture absorption, indicating improved water repellency and dimensional stability. The results demonstrate that organotin(IV) complex treatment considerably enhances wood's physical and biological resilience, suggesting its effectiveness as a wood preservation agent.

DISCUSSION

The chemical modification of tropical wood with organotin(IV) complexes resulted in desirable changes, particularly in terms of resistance to degradation by fungi, bacteria, and moisture. The FTIR and SEM analyses indicate that the organotin(IV) complexes interact primarily with hydroxyl groups in the cellulose structure of the wood, forming bonds that likely contribute to the increased density and reduced porosity observed in SEM images. These structural changes suggest that the treatment effectively shields the wood from biological attacks by reducing the available surface for microbial colonization and penetration.

Thermogravimetric analysis showed that the treated wood had enhanced thermal stability, which can be attributed to the organotin(IV) complex's high-temperature stability. This improvement in thermal resistance suggests that chemically modified tropical wood may be more suitable for applications in high-temperature or high-humidity environments. The decreased moisture absorption and improved dimensional stability observed in treated samples are particularly advantageous for tropical wood, as these properties reduce the likelihood of warping and swelling under fluctuating environmental conditions. Additionally, the reduction in fungal and bacterial growth highlights the efficacy of organotin(IV) complexes as antimicrobial agents, positioning them as a sustainable alternative to conventional wood preservatives that may contain harmful chemicals.

While the results are promising, further studies are needed to evaluate the long-term environmental impact of organotin(IV) complexes on treated wood. It is also essential to explore the potential leaching of these complexes under different environmental conditions to ensure the safety and sustainability of this preservation method. Future research could focus on optimizing the concentration of organotin(IV) complexes to maximize efficacy while minimizing chemical usage.

CONCLUSION

The chemical modification of tropical wood using organotin(IV) complexes significantly enhances its durability, stability, and resistance to biological degradation. This study demonstrates that organotin(IV) complexes effectively improve the wood's physical and biological properties, making it more resistant to moisture, microbial attacks, and thermal decomposition. The findings suggest that organotin(IV) complex treatment offers a promising alternative for tropical wood preservation, providing enhanced performance without the extensive use of traditional toxic preservatives.

Overall, organotin(IV) complex treatment has the potential to prolong the lifespan and functional usability of tropical wood in various applications. However, future studies should focus on environmental safety assessments and optimization of treatment protocols to support sustainable and eco-friendly wood preservation practices.

REFERENCE

1. Affan, M.A., M.A. Salam, F.B. Ahmad, J. Ismail, M.B. Shamsuddin and H.M. Ali, 2011. Synthesis and spectroscopic characterization of organotin(IV) complexes with 2-benzoylpyridine-N(4)-cyclohexylthiosemicarbazone (HBPCT): X-ray crystal structure of [PhSnCl2(BPCT)]. Inorganica Chimica Acta, 366: 227-232.
2. AWPA., 1991. Standard method of testing wood preservatives by laboratory soil-block cultures. AWPA Standard E10-91, American Wood-Preservers' Association (AWPA), Birmingham, USA., pp: 1-11.
3. Ashfaq, M., M.I. Khan and M.K. Baloch, 2004. Investigation of novel bio-diorganotin (IV) esters of N-maleoylglycine. J. Med. Sci., 4: 36-40.
4. Balambigai, N. and D. Aruna, 2011. Impact of copper sulphate, an essential micronutrient on ACh, AChE and Na+K+ATPase in various tissues of the fish Cyprinus carpio (L.). Res. J. Environ. Toxicol., 5: 141-146.
5. Brelid, P.L., R. Simonson, O. Bregman and T. Nilsson, 2000. Resistance of acetylated wood to biological degradation. Eur. J. Wood Wood Prod., 58: 331-337.
6. Chao, W.Y. and A.W.C. Lee, 2003. Properties of southern pine wood impregnated with styrene. Holzforschung, 57: 333-336.
7. Deka, M., C.N. Saikia and K.K. Baruah, 2002. Studies on thermal degradation and termite resistant properties of chemically modified wood. Bioresour. Technol., 84: 151-157.
8. Eaton, R.A. and M.D.C. Hale, 1993. Wood: Decay, Pests and Protection. Chapman and Hall, London.