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Natural Compounds for Wood Protection against Fungi

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Abstract: Wood is a renewable, versatile material with multiple applications and the largest terrestrial pool of sequestered carbon. However, it is susceptible to degradation, mainly caused by wood-decaying fungi. Since several traditional wood preservatives have been banned owing to their detrimental effects on humans and the environment, extending the lifespan of wood products using new generation natural preservatives is an imperative from the perspectives of human health and environmental protection. Several natural compounds of plant and animal origin have been tested for their fungicidal properties, including essential oils, tannins, wood extractives, alkaloids, propolis or chitosan; and their enormous potential in wood protection has been shown. Although they are not free of limitations, the potential methods to overcome their drawbacks and enhance their bioactivity already exist, such as co-impregnation with different polymers, cross-linkers, metal chelators or antioxidants. The presence of the discrepancies between laboratory tests and the field performance, as well as legislation-related problems resulting from the lack of standards defining the quality and performance of natural protective formulations, however, create an urgent need for further thorough research and arrangements. The collaboration with other industries interested in the utilisation of natural active compounds will reduce the associated costs, thus, will facilitate the successful implementation of alternative antifungal agents.

Keywords: natural wood preservatives; antifungal properties; essential oils; tannins; propolis; plant oil; plant extracts

Introduction

Wood is a natural, renewable and highly versatile material of excellent performance that has been commonly used by man since the dawn of history. It is also the largest reservoir of sequestered carbon in terrestrial environments. However, its chemical composition and structure make it prone to biodeterioration, and fungi are the main wood degraders. Traditionally, regarding the pattern of degradation, three groups of wood-decaying fungi are distinguished, i.e., brown-rot, white-rot and soft-rot. All of them degrade structural polymers of the wooden cell wall, which results in the loss of wood strength. Wood can also be attacked by moulds and blue stain. Although they do not cause significant structural damage, they adversely affect the aesthetic value of wood since their activity leads to wood discolouration. Wood becomes susceptible to fungal infestation under specific environmental conditions, i.e. moisture content above 20%, oxygen availability and a temperature between 15 and 45°C. Fungal deterioration affects then mainly outdoor wooden structures, reducing wood mechanical and aesthetical properties and significantly limits its service life. A broad range of effective synthetic wood preservatives has been applied to prevent this, including copper-based agents (i.a. chromated copper arsenate), triazoles (azaconazole, propiconazole, tebuconazole), pentachlorophenol or boronbased fungicides. Due to environmental and health concerns, however, many of them have been banned from the use, creating the need for developing alternative wood protection agents and methods based on non-toxic natural products.

Antifungal Substances of Plant Origin

Plants are a rich source of various chemical compounds, including alkaloids, flavones and flavonoids, phenolics, terpenes, tannins or quinones. Produced as secondary metabolites, they can constitute up to 30% of the dry mass of plants, playing an essential role in their protection against microbial pathogens, herbivores and different kinds of abiotic stress. Due to their specific properties resulting from the presence of particular phytochemicals, many plants have been used by humans ever since as medicines or food additives.

Chitosan in Wood Protection

Many attempts have been made to evaluate the effectiveness of chitosan in wood protection against fungi. Experiments performed in agar plates showed that the fungal growth rate decreased with an increase in chitosan concentration and molecular weight, whereby no apparent difference was seen between mould, white- and brown-rot fungi [185–189]. Generally, 1% chitosan solution totally inhibited fungal growth

Propolis in Combination with Polymers

The observed shortcomings of propolis extracts applied as wood preservatives, such as leachability from wood and a gradual decrease in antifungal activity over time [40,162], prompted researchers to search for stabilisers that would enhance the effectiveness of propolis. In wood preservation, application of some polymers, such as proteins or organosilicon compounds, proved effective in retaining fungicides in wood [14]. A similar approach was successfully applied for propolis. Woźniak et al. showed that a mixture of propolis extract with organosilicon compounds methyltrimethoxysilane and vinyltrimethoxysilane was more effective in protecting Scots pine wood against C.

Chitin and Chitosan

Chitin is a natural, white, hard, inelastic mucopolysaccharide consisting of 2-acetamido-2- deoxy-β-D-glucoses linked by β(1→4) bonds. Abundant in nature, it is the main component of exoskeletons of arthropods, including marine crustaceans such as shrimp and crabs, cell walls of fungi, spines of diatoms or the scales of fish. It is structurally comparable to cellulose, with similar low solubility and low chemical reactivity [164–166]. Chitosan is the N-deacetylated derivative of chitin. Its production is economically feasible since its main source is crustacean shells obtained as a food industry waste.

Conclusions

As can be seen, natural compounds have enormous potential in wood protection since they exhibit a broad spectrum of antimicrobial activities. They are renewable, readily available or costeffectively obtainable from waste materials, non-toxic or of much lower eco-toxicity than traditional chemical biocides, and environmentally-friendly. However, they also have some limitations, including high heterogeneity depending on the source from which they are derived (i.e., propolis, essential oils, wood extractives), lack of appropriate retention inside the impregnated wood tissue, easy leachability, selective or uneven activity against particular types of fungi, high susceptibility to biodegradation.

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