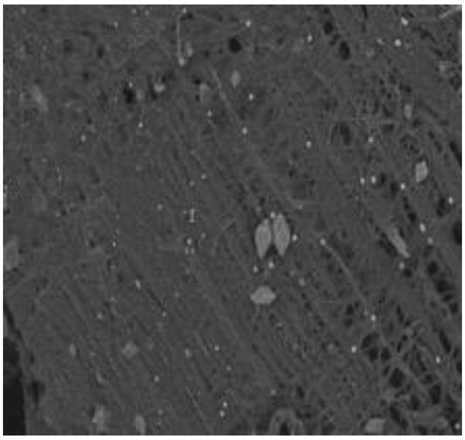
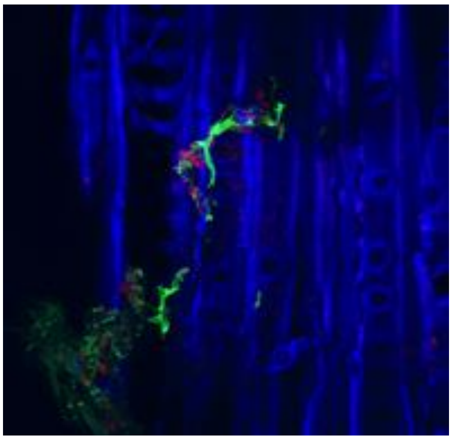
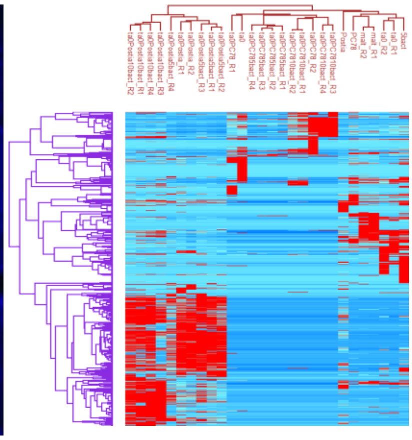
DETOXOMICS

Understanding the molecular mechanisms of fungal-bacterial-mediated detoxification of preservative treated wood

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LabEx partners: LERMAB, ENSTIB/Université de Lorraine

Collaborations: Arnaud Besserer, lecturer (LERMAB, ENSTIB/Université de Lorraine)

Thematic action concerned: WP1

Context —
The use of wood preservatives is massively exploited in the wood industry. As a result, each year, the building industry generates around 1,4 Mt of treated wood waste in France (ADEME, CODIFAB/FCBA). According to the European decision and the French decree n°2002-540, treated timbers are classified as hazardous waste. Currently, wood waste incineration pollutes the environment and damages the public health. To provide a sustainable solution to this problem, we have developed through the ANR project "WOODWASTE" (Project-ANR-18-CE04-0012) a microbial consortium of bacteria and fungi capable of detoxifying wood treated with copper/azole compounds within a few days. In addition, the DETOXOMICS project was developed to identify the molecular mechanisms of interactions between the microorganisms involved in the detoxification process and allowing the survival of the microorganisms.

Objectives —
The global objective of the project is to understand how microorganisms such as fungi and soil bacteria, individually or in consortium, are effective biocatalysts for the decontamination of wood treated with azoles and copper (Tanalith E3474). We propose two specific objectives during this project:
1) Understanding the molecular mechanisms used by the microorganisms against toxic preservatives
2) Investigating the cooperative mechanisms between fungi-bacteria during wood detoxification

Approaches —
To achieve these goals, we utilized a system biological approach “multi-Omics” to identify of new genes and pathways that are involved in the detoxification of different recalcitrant compounds. The combination of these techniques will allow us to identify specific gene regulation (transcriptomics), protein production (proteomics), and the community metabolism (metabolism) of the microbial partners. In addition, this will provide a path for self-validating findings through a combined parallel ‘omics’ approach and will ultimately result in the accelerated understanding of these complex interaction and processes, leading to better bioremediation strategies.

Key results **—** (presented as separated bullet points)
The massive production of oxalate by the brown rot fungus induces a biological leaching of copper and its immobilization in the liquid phase. Conversely, a phenomenon of biosorption of copper by the white rot fungus would allow its development on the treated wood. The two fungi would thus allow the survival of bacteria through very different mechanisms of action.
- Oxalate seems to play an important role in the fungus-bacteria interaction during the wood detoxification process.
- In the presence of high concentrations of copper, the production of oxalate induces a strong decrease of the pH in the microcosm. At the same time, the bacteria massively produce lipidic compounds in the surrounding environment when they interact with the fungi. These lipidic compounds could have a protective effect against the pH stress and chelate copper, thus participating in the detoxification process.
- The bacterial strains used in the study are able to grow in the presence of high concentrations of azoles and could potentially degrade these azoles and thus reduce its toxicity to fungi.

Main conclusions including key points of discussion —
Overall, our results suggest that fungi and bacteria can coexist and collaborate even if they compete for a similar resource in the toxic microcosm, as long as one of them participates in the detoxification process, and the level of toxicity is low enough for at least one detoxifier to survive. It is speculated that fungi could act as gatekeepers to determine which bacteria survive in a toxic microcosm.

Perspectives —
Analyses of data are still on going. Overall, the high throughput dataset generated during the DETOXOMICS project will lead us to understand the molecular dialogues involved in the wood detoxification process and will have the potential to identify new bioactive compounds. Furthermore, it will allow us characterize enzymes or metabolites involved in the detoxification. Finally, it will help us optimize the detoxification process, which could further help us develop at a large-scale process required for industry to valorize their wood wastes.

Valorization —
18th International Symposium on Microbial Ecology Lausanne, Switzerland – Presented my work
Labex Doc-post doc day and UMR internal seminars – Presented my work
Pandharikar, G.; Claudien, K.; Rose, C.; Billet, D.; Pollier, B.; Deveau, A.; Besserer, A.; Morel-Rouhier, M. Comparative Copper Resistance Strategies of Rhodonia placenta and Phanerochaete chrysosporium in a Copper/Azole-Treated Wood Microcosm. J. Fungi 2022, 8, 706.Visualization of Fungi During Wood Colonization and Decomposition by Microscopy: From Light to Electron Microscopy. A Besserer, C Rose, A Deveau Microbial Environmental Genomics (MEG), 337-361

Leveraging effect of the project—
Requests for funding have been submitted to several funders to pursue this project. For the moment, they have not been successful.