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A multiscale approach to understanding lignocellulosic biomass recalcitrance



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Evaluating polymer interplay after hot water pretreatment to investigate maize stem internode recalcitrance

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Context

Biomass recalcitrance is a key issue for the development of low-cost and sustainable biorefineries. The recalcitrance conferred by the complex structure and composition of lignocellulose limits conversion by biochemical means (pretreatment and saccharification) of many lignocellulosic resources such as the co-products of maize cultivation (stalks, leaves). One of the most widely used strategies to overcome biomass recalcitrance is the application of pretreatment technologies. Optimising pretreatment technologies requires an understanding of how the structure and organisation of these parietal polymers influence recalcitrance and the nature of changes induced by pretreatment.

To this end, water mobility at the polymer structure level was characterised on native and hydrothermally pretreated maize stalk samples. For this purpose, complementary techniques were used, including compositional, spectral and nuclear magnetic resonance (NMR) analyses.

Results

In addition to the removal of hemicelluloses (expected effect), pretreatment induces a loss of

amorphous cellulose and structural changes in lignins. Our results also show that the environment and the organisation of the lignin are important factors to consider in addition to its composition to explain recalcitrance capacity. These changes at the molecular level induce modifications in cell wall organisation through increased porosity and accessibility to cellulose. This leads to a redistribution of water, which supports the diffusion and efficiency of hydrolytic enzymes. The combination of NMR analysis techniques has been shown to be of interest in studying the environment of cellulose to explain its accessibility.

Future outlook

The recalcitrance capacity of lignocellulose is highly variable depending on the biomass considered. However, elucidation of the interactions between polymers is key to understanding the recalcitrance of lignocellulosic resources. Consequently, using the same multiscale approach on other types of lignocellulosic biomass will make it possible to optimise pretreatment and saccharification processes, and in the medium term, contribute to the development of new low-cost and sustainable biorefineries.

