

ABSTRACTS (MASTER THESIS)

Artificial lignification improves mechanical property of cellulose microfibril gel

(Graduate School of Agriculture,
Laboratory of Active Bio-based Materials, RISH, Kyoto University)

Tsubasa Yonekawa

Introduction

Plants accomplished to advance into the land from the sea about 475 million years ago, and especially tall woody plants had been flourishing by acquiring lignin since 425 million years ago. Therefore, it is considered that the mechanical property of wood was improved by depositing lignin into the cell wall. However, how the deposition of lignin, so called lignification, contributes to the mechanical property of the cell wall still remains unknown. In this research, to clarify the effects of the lignification on the mechanical property of the cell wall, artificial wood cell wall model was prepared by using cellulose microfibril hydrogel extracted from wood and artificial lignin model compound. The mechanical property of this cell wall model was studied in detail.

Experiment

By removing lignin and hemicellulose from the wood powder of hinoki (*Chamaecyparis obtusa*), the pulp water suspension was obtained. This suspension was mechanically fibrillated by the grinder to get viscous cellulose microfibril suspension. This suspension was then diluted and was filtrated to obtain wet cellulose microfibril sheet. By alkaline treatment and following neutralization, cellulose microfibril hydrogel was obtained. Then the lignin model compound was sequentially deposited inside the gel. The resulting cell wall model was subjected to observation by scanning electron microscopy and tensile test.

Results and discussion

By repeating the deposition of lignin, the surface of the cellulose microfibrils has been gradually covered by paste-like lignin, and the number of the pore was decreased (Fig. 1). The ratio of Klason lignin to cellulose content was gradually increased, and the value was 28.1% in 10 cycle. The thickness of the hydrogel was decreased by repeating the deposition of lignin, which means lignin deposition caused excess removal of water. The Young's modulus of the cell wall model was gradually increased by depositing lignin. Generally, the decrease of water content leads to higher Young's modulus. However, even taking into account the effect of the decrease in water content, lignin deposited samples showed higher Young's modulus than blank ones (Fig. 2). This is because the movement of the cellulose network was restricted by the surrounding lignin network. When the lignin deposited hydrogel was treated with 1,4-dioxane, almost all the lignin deposited was washed out. It means that the most part of lignin became agglomerate hydrophobically, and restricted cellulose network by physical bonding. Therefore, it is suggested that there exists interaction between cellulose and lignin in the real cell wall. Also, it is suggested that the mechanical property of the plant cell wall was improved by lignification even in never-dry state, by the formation of lignin network as well as the excess removal of water. Thus, it is considered that lignification enabled plants to stand alone against the gravity and to become taller.

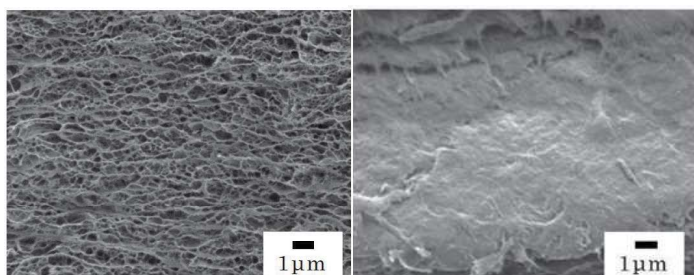


Fig. 1. Cross-sectional views of cellulose microfibril hydrogels. *left*: blank, *right*: 10 cycle of lignin deposition.

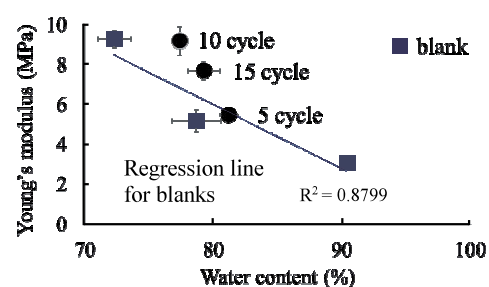


Fig. 2. Young's modulus vs water content of various hydrogels.