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Dependence of Relaxation Property of Succinylated Wood on Side-Chain Ionization

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Summary

In order to clarify the effect of side-chain ionization of partly-succinylated wood on mechanical property, relaxation rigidity was measured for wood samples immersed in water at various pH. We also made measurements in which the water medium was replaced with one of higher pH at the halfway point of the relaxation measurement.

The untreated wood shows little dependence of the relaxation rigidity on pH. On the other hand, the relaxation rigidity of partly-succinylated wood decreases with increasing pH of the medium. In the medium of pH higher than 8, the decrease in relaxation rigidity at longer time is remarkable. Furthermore, the relaxation rigidity decreases rapidly after a water medium of acidic pH is replaced with alkaline pH above 10 at a time of 10^3 sec. The addition of NaCl to the water medium reduces the decrease of relaxation rigidity.

Taking into account the results of swelling and weight gain in water medium, we conclude that the effects of pH and salt on the mechanical relaxation property are due to the ionization of side chain. The decrease of relaxation rigidity can be explained as follows. Since main chain of succinylated wood repels one another electrostatically at higher degree of ionization of side chain, the wood swells until the swelling pressure is balanced by the elastic repulsive force due to the ultra structure of wood. Under these conditions, the interaction between main chains becomes weak. The relaxation rigidity is, therefore, reduced, and the remarkable relaxation occurs in the medium of higher pH.

Introduction

It is well-known that the conformation of polyelectrolyte depends remarkably on the degree of ionization (Peller 1959; Wada 1960; Strauss *et al.* 1954; Schneider *et al.* 1954; Harris *et al.* 1954). The structure is transformed from random coil to rodlike conformation with an increase in the degree of ionization. The change of conformation is related to electrostatic repulsion of side chain. In a previous report (Nakano 1993), we assumed that one of the factors related to the decrease of relaxation rigidity Gr with an increase in the amount of side chains of carboxymethylated wood is the electrostatic repulsion of ionized side chain; the interaction between the main chains decreases because of expanded space among wood components. Thus, in analogy with polyelectrolyte, we can predict that relaxation properties of chemically-modified wood with a dissociative group such as the carboxyl group in side chain depend upon the degree of ionization.

In the present report, we will try to clarify the relationship between the degree of ionization of side chain and the mobility of wood components. We examine the effect of pH and the content of salt on relaxation properties in aqueous solution for succinylated wood (SW) with carboxyl group in side chain; pH is related to the degree of ionization, and the content of salt to the screening effect. In the experiment, Japanese ash (*Fraxinus mandshurica* Rupr. var. *japonica* Maxim.) was used as specimens.

Experimental

Preparation of specimens

The wood specimens were prepared from Japanese ash (*Fraxinus mandshurica* Rupr. var. *japonica* Maxim.) with rectangular dimension of 0.1 (L) × 7 (R) × 1 (T) cm; L, R, and T are longitudinal, radial, and tangential cutting direction, respectively. Before succinylation, the specimens were extracted with a mixed solvent of alcohol/benzene (1/2, v/v) for 24 hrs. Succinylation was made by a method reported previously (Nakano *et al.* 1986). At pH 3–8, mixed solutions of citric acid (0.1 mol/l) and sodium phosphate (0.2 mol/l) as buffer were used. At pH 9–10, solutions of sodium carbonate (0.2 mol/l) and sodium hydrogencarbonate (0.2 mol/l) were used. Sodium chloride (NaCl) solution was used as salt solution.

Measurement of stress relaxation

Two kinds of measurements were made in solution at 30°C under two conditions using the same torsional relaxation apparatus as we used in the previous work (Nakano *et al.* 1986). One was carried out in fixed pH solution; the other in solution varying from low pH to high during measurement. Before stress relaxation measurement, the specimens were impregnated with the solution under reduced pressure, and then were allowed to soak in the solution at room temperature overnight.