HYDROGEN PEROXIDE AND IRON: A PROPOSED SYSTEM FOR DECOMPOSITION OF WOOD BY BROWN-ROT BASIDIOMYCETES

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(Received 10 January 1974)

ABSTRACT

Low concentrations of H_2O_2 and Fe^{++} caused rapid weight loss of wood of sweetgum and loblolly pine. The degree of polymerization of cellulose in treated woods decreased rapidly at low weight loss and then diminished gradually. The alkali solubility of exposed woods increased rapidly at low weight loss and was inversely related to the degree of polymerization. The H_2O_2-Fe system solubilized hemicelluloses of both woods more readily than cellulose. Lignin of sweetgum, but not pine, was changed so that it was solubilized by strong acid hydrolysis. The optimal pH for weight loss was about 3.3 for sweetgum and 3.0 for pine. Wood of both species absorbed much of the available Fe from solution.

The literature suggests that brown-rot is oxidative rather than being strictly hydrolytic. The H_2O_2-Fe^{++} system oxidizes cotton cellulose, and it essentially reproduced in wood and wood cellulose, characteristics of brown-rot basidiomycetes. These fungi produce H_2O_2 from native substrates in wood (Koenigs, 1974) and the optimal pH for degradation. Thus, it is proposed that these fungi may attack cellulose and partly decay wood via an H_2O_2-Fe^{++} system.

Additional keywords: Pinus taeda, Liquidambar styraciflua, wood decay, weight loss, cellulolysis, depolymerization, lignin solubility.

Microbial decomposition of cellulose is considered to result solely from the direct enzymatic interaction of cellulase components. These fractions have been isolated and their individual (Reese and Mandels 1971) and synergistic effects reported (Li et al. 1965; Mandels and Reese 1964; Reese and Gilligan 1954; Selby 1969; Selby and Maitland 1967; Wood 1968). Enzymatic hydrolysis usually involves random rather than endwise attack as shown by depolymerization experiments with cotton cellulose (Reese 1957; Reese et al. 1957) and delignified wood cellulose (King 1968) or its derivatives (Norkrans and Rånby 1956).

White-rot basidiomycetes, also, produce cellulase components capable of randomly attacking delignified cellulose (see references in Cowling and Brown 1969; Gasgoine and Gasgoine 1960; Highley 1973; Norkrans 1967); however, these preparations have little effect on native wood (Pew 1957). The fungi themselves depolymerize the cellulose so that at any stage of decay the bulk of the residual cellulose is not depolymerized (Cowling 1961; Kayama 1961; Kayama 1962a, b, c). This restricted depolymerization by cellulase in wood is attributed to protection by the lignin and hemicelluloses surrounding the cellulose, to the fact that capillary pores are too small to admit the cellulase molecule and to several other factors (Cowling and Brown 1969).

In contrast to white-rot basidiomycetes, brown-rot fungi lack a C_1 enzyme (Highley 1973), yet they depolymerize wood cellulose to 20% of the original chain length at only 10% weight loss (Cowling 1961; Kayama 1962a). These differences and other characteristics of the wood rotted by these two groups of basidiomycetes (see discussion in Cowling 1961) suggest that they may employ basically different cellulolytic systems. Some effects of brown-rot fungi resemble those created by acid hydrolysis or oxidative degradation, but wood cellulose is notably resistant to both weak acids