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Short Note

TEM Examination of Surface Characteristics of Rubberwood (*Hevea brasiliensis*) HTMP Fibers

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Introduction

Interest in the use of wood fiber products is growing rapidly. It is therefore important to obtain detailed information on fiber properties (Park *et al.* 2001), with particular emphasis on the chemical and physical characteristics of fiber surfaces, as the properties of composite products, such as medium density fiberboard (MDF), are largely determined by surface features of fibers (Donaldson and Lomax 1989; Butterfield *et al.* 1992; Singh and McDonald 2000).

As the place of fracture within wood tissues determines the surface properties of mechanical fibers, it is not surprising that considerable attention has been devoted to understanding the behavior of wood during mechanical fracturing. The available information suggests that fracture properties are determined by many factors, including wood species, wood density, moisture content, cell dimension, microfibril angle and the nature and direction of applied force or stress (reviewed in Lai and Iwamida 1993; Donaldson 1996; Schmitt *et al.* 1996). The effect of chemical composition, cell wall texture and the pattern of distribution of cell wall substances on the fracture behavior is less well understood. It is known that lignin distribution may determine the location of fracture within the cell wall (Donaldson 1995), and recent observations have shown a close correspondence between the morphology of mechanically induced radial micro-checks in the S_2 layer of normal and mild compression wood cells and that of the radial striations in this cell wall layer, resulting from heterogeneity in the micro-distribution of lignin (Singh *et al.* 1998, 2002; Singh and Daniel 2001). These observations also suggest that both the amount and pattern of lignin distribution may have an impact on the fracture behavior of cell walls. The use of a mechanical property microprobe for understanding the hardness and mechanical characteristics of the middle lamella is also providing relevant information (Wimmer and Lucas 1997).

Chemical and mechanical fibers related to paper products have been extensively studied by microscopy and other techniques. Interest in understanding the properties of thermo-mechanical (TMP) and high temperature thermo-mechanical (HTMP) fibers, which are widely used in the manufacture of MDF products, is also growing (Koran 1970, 1987; Bruun and Lindroos 1983; Kojima and Kayama 1985; Moss *et al.* 1993; McDonald and Singh 1996; McDonald *et al.* 1997; Singh and McDonald 2000; Snell *et al.* 2001). Recent investigations using transmission electron microscopy have characterized the surface features of radiata pine (*Pinus radiata*) HTMP fibers (McDonald and Singh 1996; McDonald *et al.* 1997), and a preliminary study comparing commercial radiata pine and rubberwood (*Hevea brasiliensis*) MDF fibers (Singh and McDonald 2000) suggests significant differences between the two wood species with regard to the fracture behavior of cell walls and the surface characteristics of fibers.

The surface features of rubberwood HTMP fibers were studied in detail in the present study, providing substantial new information on the chemical, microtopographical and ultrastructural characteristics of the exposed fiber surfaces.

Materials and Methods

The rubberwood high temperature thermo-mechanical (HTMP) fibers examined in this study were obtained through Forest Research Institute Malaysia (FRIM), Kuala Lumpur. For transmission electron microscopy (TEM), the fiber samples were dehydrated in acetone prior to embedding in Spurr's low viscosity resin (Spurr 1969). Ultrathin sections from the embedded blocks were cut on a RMC MT-X ultramicrotome using a diamond knife. Sections were then stained with 1 % potassium permanganate ($KMnO_4$) prepared in 0.1 % sodium citrate and examined with a JEOL 1010 TEM. $KMnO_4$ was