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Short Note

Properties of Southern Pine Wood Impregnated with Styrene

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Introduction

A shortage of high quality hardwood has driven manufacturers to search for alternative resources such as softwood. The hardness of softwood, in certain applications, becomes the crucial factor for this substitution. In the past, various treatments have been used to stabilize wood from changes due to moisture and to improve its physical and mechanical properties and bio-deterioration resistance. Chemically treating woods with styrene (Langwig *et al.* 1968, 1969; Meyer and Loos 1969), methyl methacrylate (Noah and Foudjet 1988), vinyl acetate and other chemicals (Mathias *et al.* 1991; Yalimkilic *et al.* 1998, 1999; Solpan and Guven 1999) have shown promising improvements. Chemical treatment with additional compression also brings in a new dimension of wood property improvement. In this study we focused on the improvement in hardness of southern pine wood by styrene impregnation. Regular diffusion and vacuum impregnation were used to transport the styrene into the wood, and styrene was then polymerized *in situ* by a catalyst-heat process. The hardness, density, weight gain and water absorption were determined.

Materials and Methods

Materials

Eight wood specimens, measuring 5.08 cm × 5.08 cm × 5.08 cm in the longitudinal, radial and tangential directions were prepared from air-dried southern pine for each untreated and treated condition. Wood specimens were selected without visible defects and with the wood density as close to 0.5 g/cm^3 as possible. Specimens were sanded to produce smooth surfaces and conditioned at 21 °C with 50 % relative humidity (R.H.) for two weeks before the treatment. The moisture content of the wood after conditioning was about 8 %. The styrene solution consisted of 100 parts styrene, 2 parts 2,2'-azobisisobutyronitrile and 5 parts divinyl benzene by weight. Azobisisobutyronitrile was a catalyst while divinyl benzene was a crosslinking agent.

Impregnation process

Soaking and vacuum processes were used for the impregnation of the wood. In the soaking process, wood specimens were submerged in the styrene solution at room temperature for 1, 2, 4 and 8 days. The reactor was shielded with aluminum foil to prevent the possible polymerization of styrene by light. However, the styrene solution became a semi-gel after 4 days at room temperature, a gel after 8 days and a solid after 28 days, as a result of the polymerization of styrene solution.

To achieve better penetration of the chemical into the wood during the impregnation process, a vacuum of 7.5 micrometer Hg was applied while the wood samples were submerged in the styrene solution. The duration of the vacuum was 1, 2.5, 5, 10 and 20 min. After both impregnation treatments, wood samples were sealed with aluminum foil and cured in an oven at a temperature of 65 °C for 96 h. The extended curing time was used to ensure the full polymerization of styrene in the wood blocks. The excess polystyrene on the wood surface was carefully sanded away before measuring the weight and the dimensions of the treated wood.

Weight gain (%)

The weight gain of the wood after the chemical impregnation was calculated by the following equation:

$$\text{Weight Gain (\%)} \frac{\text{Weight of wood}_{\text{after treatment}} - \text{Weight of wood}_{\text{before treatment}}}{\text{Weight of wood}_{\text{before treatment}}}$$

Water absorption

The untreated and treated wood samples were submerged in water for 24 h according to the American Society for Testing & Materials D-1037 method. The excess water on the soaked samples was wiped off, and the weight changes of the wood were measured.

Hardness of wood

The modified Janka ball hardness test method (ASTM D-143 or D-1037, 1998) was used to determine the wood hardness. Hardness is defined as the load at which the ball is penetrated to one half of its diameter (1.1278 cm). The hardness of tangential-longitudinal (T-L) and radial-longitudinal (R-L) surfaces of wood were determined.

Statistical analysis

The effects of different treatments and treatment times on the weight gain, density, water absorption and hardness of wood