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Effect of copper based preservatives treatment of the properties of southern pine LVL

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ABSTRACT

This work reports the effect of copper based preservatives treatment namely copper azole (CA-B), micronized copper azole (MicroCA) and alkaline copper quaternary (ACQ-C) on the physical and mechanical properties of southern pine laminated veneer lumber (LVL) bonded with cross-linked thermoplastic PVAc (XPVAc) or thermoset phenol formaldehyde (PF) adhesives. Three treatment procedures, pre-dip treatment of veneers, vacuum-pressure treatment of LVL and post-dip treatment of LVL were used for treatments. The preservatives retention of non-pressure treated veneers and LVL vary from 0.67 to 1.9 kg/m^3 while the retentions for samples pressure treated vary from 4.0 to 9.6 kg/m^3 also similar to retention for ground contact applications for solid wood. Density, water absorption, thickness swelling, flexural modulus of rupture (MOR) and modulus of elasticity (MOE), hardness, tensile shear strength, wood failure and delaminations were evaluated and no significant reduction due to treatments was observed, suggesting that such process can be used to treat LVL and therefore increase the service life of such products against biological deterioration.

1. Introduction

Wood products including engineered wood composites are used in applications where biological deterioration is a menace. Treatments using cost effective preservatives against biological hazards is paramount to increase the service life of such products for exterior applications. Laminated veneer lumber (LVL) is commonly used for structural and non-structural indoor and outdoor members in construction where biological degradation may occur. Plantation grown wood species with high percentage of juvenile wood, low extractives content, and that have relatively low natural decay and insect resistance are currently used to manufacture LVL. Lack of biological durability will more likely limit their wide acceptance in different applications.

Similar to solid wood and other engineered wood products such as glullam, wood preservatives may be employed to improve the decay and insect resistance of LVL, but information on potential impact of wood preservatives on the manufacturing process and the product performance depends on the type of preservatives and sometimes on the wood species also. Such information is needed to expand the potential market use of LVL for outdoor applications and or others applications where biological degradation is a threat such as door jambs, furniture, flooring and ceiling in termites and powder beetles infested regions.

Several processes can be used to incorporate wood preservatives in LVL. A non-pressure treatment may be used to dip-treat wood veneers before manufacturing or to dip treat LVL already manufactured. Such treatments are usually designed to provide envelop treatment with low solutions uptake and very little penetration during the treatments.

Vacuum and pressure can be employed to vary the level of treating solutions uptake, and penetrations. Glue line treatments which consist in incorporating wood preservatives in the glue mix have been also proposed as a strategy to include wood preservatives in wood composites [19,21]. One of the potential problems of incorporation of wood preservatives in wood composites is the potential interference with the gluing process therefore modifying the desired physical and mechanical performance of the end products such as swelling, dimensional stability and bending strength. LVL pre or post treated with preservative must provide adequate protection against biological deterioration without sacrificing mechanical or physical properties.

Waterborne wood preservatives systems such as alkaline copper based quaternary or azoles and/or borates are well established effective wood preservatives for solid wood [6,28]. Recently, waterborne formulations containing micronized copper carbonates and a co-biocide to control copper tolerant fungi have been introduced commercially for the treatment of solid wood. Their

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advantages are relative low cost, low level of copper leaching from treated wood and low corrosiveness when in contact with metal fasteners and connectors. A review of copper based formulations preservatives including micronized copper was published recently [14].

A comprehensive review describing potential parameters susceptible to reduce the properties of treated wood was reported earlier by Winandy [31]. He reported that the important factors affecting strength properties of the treated wood and/or wood composites include the type and amount of chemicals uptake during treatments, the wood species, the pH of the treating solution, the pre- and post-treatments conditions such as drying temperature, treatments parameters include vacuum and pressure levels and durations. Early works reported that preservative treatments such as CCA, ACQ and CA may affect the adhesive bonding properties of wood composites [11,15,22,18,23]. Little information is available on the effect of the use of emerging micronized copper based system on the properties of treated wood and on commercial adhesive such as phenol formaldehyde.

This study investigates the effect of micronized copper system treated veneers on the properties of resultant LVL. As references, CA and ACQ treated veneers were also used. Two commercial adhesives were employed to laboratory manufacture LVL; namely cross-linked polyvinyl acetate designed for exterior applications and phenol formaldehyde adhesive grade for engineered wood products.

2. Materials and methods

2.1. Wood veneers

Kiln-dried rotary peeled southern pine veneers measuring 3.3 ± 0.2 mm thick by 1.2 m width by 2.4 m long were obtained from a mill located in Louisiana, USA. The veneer sheets were clipped to a length of 560 mm and width of 510 mm. Veneers sheets were visually selected based on the presence of defects that may affect the strength and the appearance of the final products. Visually sound veneers with small or no insect holes, smooth surface, no splits, and no decay were selected and used to fabricate 9 ± 1 mm thick three-ply LVL. The moisture content of veneers used to fabricate the LVL was 7 ± 1%.

2.2. Adhesives

Two commercial adhesives namely phenol formaldehyde (PF) resin and cross-linked polyvinyl acetate (XPVAc) were used for the manufacture of three-ply LVL boards. A commercial grade PF resin labeled GP 421G83 RESI–MIX for the manufacture of engineered plywood was used. as received for the production of LVL. A XPVAc labeled PC-2002 one-part type II ready-to-use cross-linked polyvinyl acetate adhesive was purchased and used without further modification. The properties of the two commercially available adhesives are listed in Table 1.

2.3. Preservatives

Three waterborne wood preservatives; copper azole-type B (CA-B), micronized copper azole (MCA) and alkaline copper quaternary-type D (ACQ-D) were used for the treatments of veneers and LVL. CA-B contains copper carbonate solubilized with monoethanolamine with tebuconazole added as co-biocide to protect against copper tolerant fungi. The ratio of copper to azole in percentage by weight is close to 96%. ACQ-D is a formulation of copper carbonate solubilized with mono-ethanolamine with dodecyl dimethyl ammonium carbonate added as co-biocide for copper tolerant fungi with ratio of copper as copper oxide to DDAC of 2–1 and ratio of copper to monoethanolamine of 1–3. MicroCA is made of micronized copper carbonate with average particle size of 1 μm mixed with tebuconazole at the same ratio as in CA-B. ACQ-D was supplied by Osmose while CA-B and MicroCA were obtained from PhibroWood. CA-B and MicroCA treating solution strength of 0.8% and 1.2% for ACQ type D were prepared from stock solutions using Distilled water and employed for treatments. The pH values of MicroCA, CA-B and ACQ-C treating solutions measured before the treatment were 8.0 ± 0.2, 9.4 ± 0.1 and 9.2 ± 0.2, respectively.

2.4. Preservative treatments

Three processes were used, namely pre-dip treatment of veneers before use in the manufacture of LVL (Pre-dip), vacuum-pressure treatment of LVL (Pressure) and the dip treatment of LVL (Post-dip).

2.4.1. Pre-dip treatment of veneers

Pre-dip treatment consists in submerging southern pine veneers in treating solution for 5–6 min duration. Initial weights and weights after immersion of veneers were recorded and used to calculate the average uptake of the treating solution. Subsequently, treated veneers were air-dried at 21 ± 2 °C and 65 ± 5% relative humidity for about a month or until constant weight. The moisture content of treated and conditioned veneers were 9 ± 1% before use in the manufacture of LVL.

2.4.2. Pressure treatment

Laboratory manufactured LVL samples measuring 9 mm by 152 mm by 300 mm were pressure treated using an initial vacuum level of 85 ± 5 kPa for 25 min followed by pressure at 1.03 ± 0.03 MPa level for 30 min. Pressure treated LVL specimens were removed from the treating tank, wiped free of excessive preservative on the surface and weighed to calculate the amount of preservative uptake during treatment.

2.4.3. Post-dip treatment

LVL measuring 9 mm by 152 mm by 300 mm were impregnated with preservatives by dipping in the preservative solution for 30 min duration. The average uptake of the treating solution was calculated from the weight gain by the samples. Treated LVL was first air-dried for about two to three weeks to facilitate any potential chemical reactions between preservatives and wood-adhesive. The air-dried treated LVL were transferred in conditioning room

Table 1
Properties of adhesives and processing parameters used to manufacture southern pine LVL.

Adhesive	% volatile (w/w)	Properties of adhesives			Processing parameters		
		Density (g/cc)	pH (at 20 °C)	Viscosity (at 25 °C) (mPa s)	Spread rate (g/m^2)	Hot press settings	
						Platen temperature (°C)	Platen pressure (MPa)
XPVAc	53 ± 3	1.06 ± 0.1	3.0 ± 0.5	5000 ± 500	280 ± 10	50 ± 2	2.1 ± 0.2
PF	55 ± 5	1.20 ± 0.1	12.0 ± 0.5	1500 ± 100	280 ± 10	140 ± 2	2.1 ± 0.2