Properties of a Novel Wood-plastic Composite

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INTRODUCTION

Wood flour and fibers are excellent fillers for thermoplastics because of their low density, low cost, high strength and stiffness, desirable fiber aspect ratio, flexibility during processing, and biodegradability (Felix and Gatenholm 1991, Collier et al. 1995, Hwang et al. 2005, 2007, 2008). However, satisfactory dispersion of wood fillers in the matrices of thermoplastics has always been a problem caused by the hydrophilic nature of wood and the hydrophobic nature of plastic (Felix et al. 1994). The surface characteristics of cellulosic fibers prohibit the formation of a durable interface in the plastic composites and causes failure in stress transfer from one phase to another.

The objective of this study was to determine the termite resistance, internal bond (IB) strength, and dimensional stability of panels consisting of a mixed wood particle/recycled plastic composite.

MATERIALS AND METHODS

Wood particles were obtained from the dry end of a local particleboard plant. The particles were classified as core furnish, stored in plastic bag in drum, and used without further preparation. The polyethylene plastic was shredded, chilled in cooler, then reduced with a disc definer into powder. Each furnish was weighed to yield a core density of about 50 pcf based on ovendry weight and volume at 5% moisture content (MC) and placed in a rotation drum-type blender. All panels (14x20x0.5-in.) were prepared in the laboratory with three replicates.

We evaluated the bonding strength and dimensional stability of mixed wood particle/ recycled plastic panels (MWP) and traditional wood particleboard (WP). Two different urea formaldehyde (UF) resins were used in amounts equal to 6 % of the ovendry weight of particles and applied by an air-atomizing nozzle. The resin, prepared in the laboratory, was formulated as 51 percent resin solids reacting at pH 5.1 with molar ratio of formaldehyde to urea of 1.2. The commercial resin had a 64.8% resin solids. The panels were prepared in a laboratory hot press using a press temperature of 340° F. Closed press time was 3 min. and 15 s.

The particles, after blending, were carefully felted on a caul plate in a forming box. The formed mat was transferred immediately to a 20x20 in.^{2} single-opening hot press at 340 ° F. Sufficient pressure (about 400 psi) was applied so that the platens closed to ½-inch stops in approximately 45 seconds. All boards were conditioned in a chamber at 50% relative humidity (RH) and 80° F before testing. After conditioning, each board was cut to yield 10 IB specimens (2x2 in.) and 4 dimensional stability specimens (4x6 in.) for both linear expansion (LE) and thickness swell (TS). The dimensional stability tests consisted of soaking the samples in tap-water for 24 h. Thickness and lengths were measured before and after soaking (ASTM 1999). Laboratory termite testing was done in accordance with AWPA E1-06 (AWPA 2007). The data was analyzed in SAS (2008) by using analysis of variance (ANOVA). Also, means were separated by Duncan's multiple range test at the 0.05 level of probability.

RESULTS

Table 1 summarizes the mean IB, TS, and LE of the panels. The Duncan's multiple range test (Table 2) indicated that the differences between IB of MWP panels and WP were not significant. Moreover, the resin type had no significant effect on IB. Therefore, the addition of 25% recycled plastic did not have an adverse effect on bonding.

TS of MWP were surprisingly significantly less than that of WP. The improvements in thickness swell for MWPs were 39% and 44 %, for the laboratory resin and commercial resin, respectively, as compared to that of WP. Mean TS for the commercial resin (16.6%) was slightly lower than that of the laboratory produced resin (19.3%).

Mean LE for MWPs (0.188%) were also significantly lower than that of WP (0.228%). Again, the commercial resin yielded a slightly lower LE (0.191%) than that of laboratory resin (0.225%).

The samples showed fair resistance to the Formosan termite (Table 3). The mean mortality, weight loss, and rating of the WPC samples were 34.55%, 11.16%, and 7.8, respectively.

CONCLUSIONS

Experiments were performed to determine the potential of panels consisting of a veneer face and a particle board core comprised of a mixed wood particle/recycled plastic composite. First, 1/2 –in. thick particleboards were made to evaluate termite resistance, internal bond (IB) strength and dimensional stability. The addition of 25% recycled plastic in mixed particle/plastic panels (MWP) did not adversely affect bonding strength as compared to wood particleboard (WP) but resulted in substantial improvement in dimensional stability of the panels. Thickness swell of MWP decreased between 39 to 44 % and yielded significantly lower linear expansion (0.188%) than that of WP. The samples showed fair resistance to the Formosan termite.

This finding suggests that MWP panels offer potential for the development of structural panel products such as a new structural housing and other flooring systems. The termite performance of the panels must be improved to use the panels in Formosan termite infested areas.

LITERATURE CITED

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Table 1. Internal bond (IB) strength and dimensional stability of panels constructed with mixed wood particle/recycled plastic composite and wood particleboards.

Resin	Panel construction	IB	TS[1]	LE[2]
		(psi)	%	%
Laboratory formulated UF resin				
	MWP[3]	110.3	14.60	0.194
	WP[4]	105.6	23.97	0.255
Commercial UF resin				
	MWP	94.7	11.88	0.182
	WP	101.6	21.37	0.200

[1]Thickness swell.
[2]Linear expansion.
[3]Denotes mixed wood particle/recycled plastic composite.
[4]Denotes wood particleboard.

Table 2. Duncan's multiple range tests for internal bond (IB), linear expansion (LE), and thickness swell (TS).

Variable	IB (psi)	LE (%)	TS (%)
Resins			
Laboratory resin	108.0 A	0.225 A	19.3 A
Commercial resin	98.1 A	0.191 B	16.6 A
Core construction			
Wood	103.6 A	0.228 A	22.7 A
Wood/plastic	102.5 A	0.188 B	13.2 B

Means values for each combination of variable and test (IB, LE, and TS) with similar letters are not significantly different at alpha = 0.05.

Table 3. Summary of Formosan termite performance using the AWPA E1-06 test. Samples were taken from the WPC panels made with commercial UF resin. Means with the same letter for a particular property are not different at alpha = 0.05 according to the LSD test procedure.

Treatment ID	Mortality (%)	Wt. Loss (%)	Avg. Rating
Control	12.50 (A)	43.72 (A)	2.6 (A)
Wood Plastic Composite	34.55 (B)	11.16 (B)	7.8 (B)