EFFECTS OF WEATHERING ON COLOR LOSS OF NATURAL FIBER THERMOPLASTIC COMPOSITES[1]

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Introduction

The technology currently exists to manufacture natural fiber-thermoplastic composites from recycled materials. Development of commodity building products from these composites would open huge markets for waste-based materials in the United States. To date, the construction industry has only accepted wood-thermoplastic composite lumber and only for limited applications. In a little more than a decade, the use of composite decking has grown to about 4% of the exterior decking market. Even larger markets within the building industry could be developed, such as the roofing market. However, a lack of durability performance data and reluctance by homebuilders to use undemonstrated products has hampered market development.

Because thermoplastics are polymeric in nature, they are susceptible to environmental stresses. These stresses include, but aren't limited to, thermal and moisture induced expansion and contraction, light (UV), and chemical agents such as organic solvents, ozone, acids, and bases. The objective of this ongoing study is to investigate the effects of weathering on natural fiber-thermoplastic composites intended for roofing applications. Because color fade is an important performance factor for roofing products, preliminary results are presented that indicate the effect of weathering on the color fade of selected composite formulations.

Materials and Specimen Manufacture

Two recycled thermoplastics (high density polyethylene (HDPE) and polypropylene (PP)), five natural fibers (wood, coconut coir, sisal, and jute), and a variety of additives (UV stabilizers, fungicides, colorants, and compatibilizers) were evaluated in this study. Because of length restrictions, only results for selected formulations are presented here.

Global Resources Technologies, LLC, compounded the formulations using a proprietary process and compression-molded the material into 6- by 6- by 1/8-in. (150- by 150- by 3-mm) flat plates. Fiber contents ranged from 0% to 70% by weight.

Test specimens were cut from the manufactured plates and were 1 in. x 2.5 in. x 1/8 in. (25 mm x 64mm x 3 mm) in size. To allow flexural testing after weatherometer exposure. the specimens were sized in reference to the American Society of Testing and Materials (ASTM) Standard D790-96a [1]. The flexural tests are currently underway.

Weatherometer Testing

In the United States, the International Conference of Building Officials (ICBO) publishes one of three regional building codes (Uniform Building Code). In addition, ICBO also publishes "acceptance criteria" for a variety of products. In one such set of acceptance criteria, entitled Acceptance Criteria for Special Roofing Systems, durability test procedures for synthetic roofing systems are described [2]. The durability tests include an evaluation of resistance to water, UV

[1]The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

radiation, freeze-thaw, and temperature cycling. This paper includes the results of tests that subjected composite roofing material to UV radiation. These tests are referenced in the acceptance criteria.

The ICBO standard references the use of a weatherometer device (described in detail in ASTM G23-96 [3]), which automatically controls and cycles temperature and humidity. We used an enclosed Xenon-arc lamp weatherometer chamber at the USDA Forest Service, Forest Products Laboratory (FPL), that meets the specifications of ASTM G23-96. The specimen drum inside the weatherometer chamber operates at 1 rpm and was set to provide 102 min of light followed by 18 min of light and water spray (a standard exposure cycle). Specimen color intensity was measured and reported at 0; 200; 400; 700; 1,000; and 1,500 h of exposure.

Color Loss Measurement

The color intensity of the exposed and unexposed (control) specimens was measured using a Minolta CR-200 Chroma Meter. Three parameters are measured with this device: value (or amount of reflected light), chroma, and hue. Our primary interest was measuring value. This factor provides a quantitative measure of color loss and would indicate the most ideal formulation (from a color fade standpoint) for roofing applications.

Results and Conclusions

Data on the color loss of the natural fiber-plastic specimens were analyzed and plotted to indicate trends in performance. A statistical evaluation of the test results for each formulation indicated that the variability in color fade was low (<10% coefficient of variation for the unexposed specimens and <5% coefficient of variation for the exposed specimens). For this reason, only averages are presented.

Figure 1 indicates the effect of UV exposure on specimens containing wood flour. It is apparent from Figure 1 that the PP-based composites faded at a more rapid rate than the HDPE-based composites and that the specimens with higher wood flour content faded somewhat more than the specimens with lower wood flour content. Figure 2 shows color loss that UV exposure caused on the fibers in wood-thermoplastic composites.

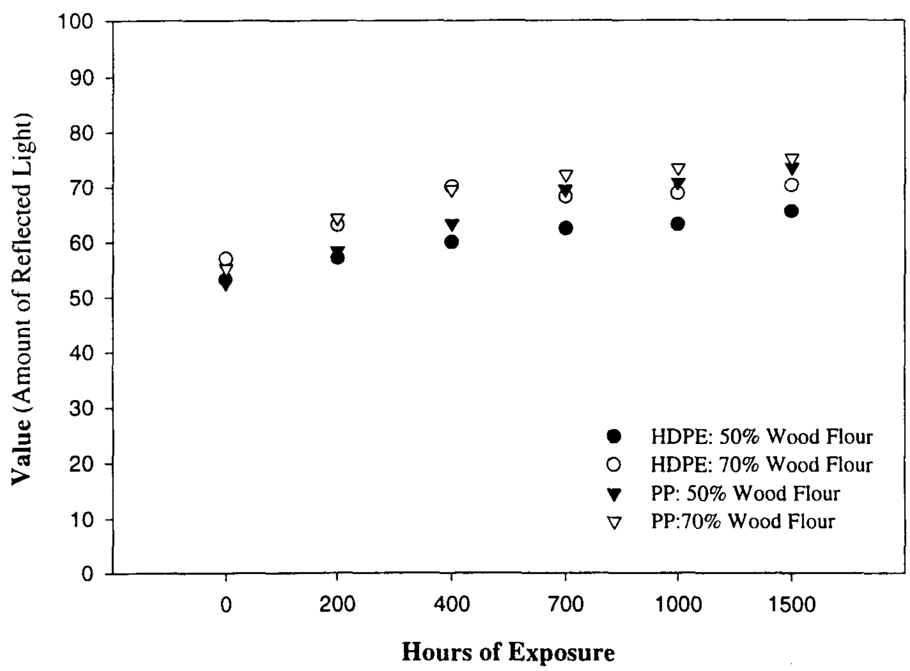

Fig. 1. Effect of Weatherometer Exposure on Color Fade of Unpigmented Wood Flour-Thermoplastic Composites (No additives)

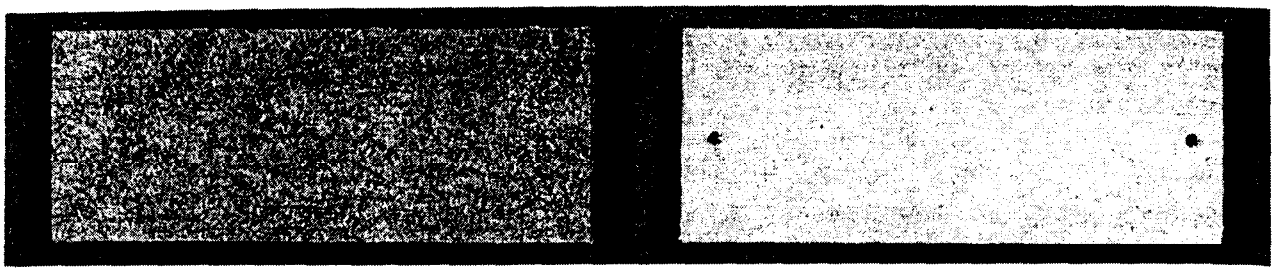

Fig. 2. PP Test Specimens with 50% Wood FlourLeft, Unweathered specimen; Right, Weathered Specimen (1,500 hours)

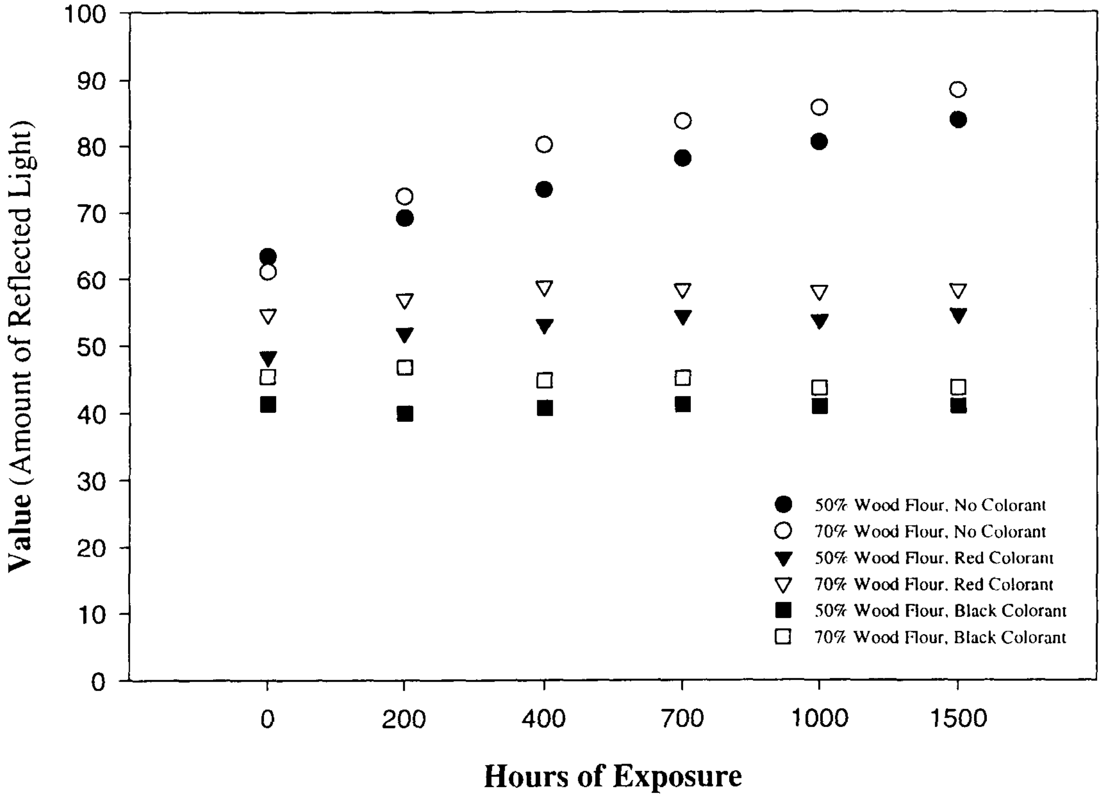

Fig. 3. Effects of Pigments and Fiber Content on Color Fade of HDPE-Wood Flour Composites (Only colorant added)

Figure 3 shows the effect of pigments on the color fade of the tested wood-HDPE composite. Results are similar for PP. It seems that the darker the pigment is, the better it is able to hide the graying fibers. The pigments used are UV transparent so it is likely that there is some fiber lightening below the surface from UV transmitted through the pigmented resin. Figure 4 shows that there is little lightening of composites with added black colorant. This confirms the effect of colorants on minimizing color fade.

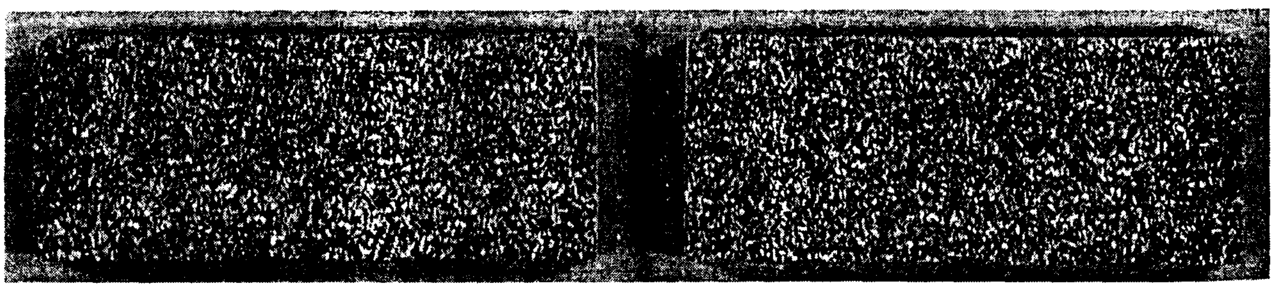

Fig. 4. Test Specimen with Fe_2O_3 ColorantLeft, Unweathered specimen: Right, Weathered Specimen (1,500 hours)

Figure 5 shows the effects of the addition of a hindered-amine UV inhibitor on the color fade of wood-thermoplastic composites. The color fade of pure PP resin is most affected by UV inhibitor addition, while the presence of wood flour apparently renders the UV inhibitor ineffective in preventing color fade.

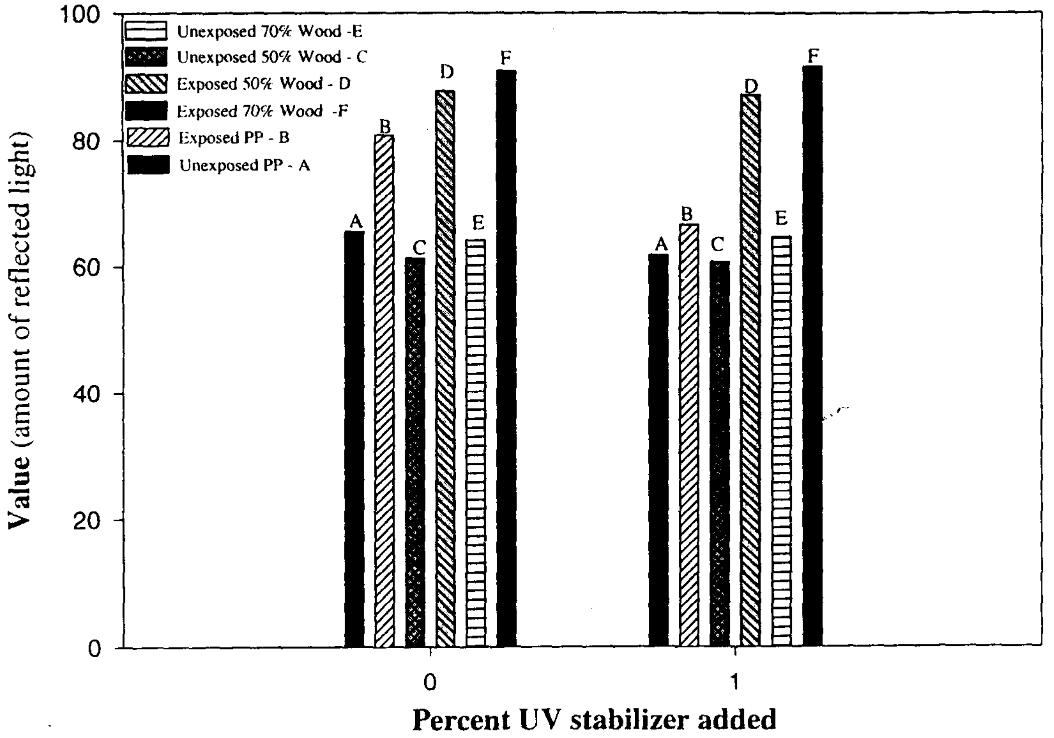

Fig. 5. Effect of UV Stabilizer on Color Fade of Wood Flour-PP Composites

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Proceedings from the

Third International Symposium on Natural Polymers and Composites - ISNaPol/2000

and the Workshop on Progress in Production and Processing of Cellulosic Fibres and Natural Polymers

May, 14-17, 2000
Hotel Fazenda Fonte Colina Verde
São Pedro, SP, BRAZIL.

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São Carlos, 2000