INJECTION-MOLDED COMPOSITES FROM KENAF AND RECYCLED PLASTIC

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ABSTRACT

Kenaf-based thermoplastic composites were developed and evaluated in this study. The kenaf stems were collected from farms in Central Illinois. The kenaf fibers were blended with commercial virgin plastic or polypropylene and with recycled plastics or low-cost polyethylene in form of post-consumer film wastes and shrink wraps.

Investigations on the fiber properties and chemical compositions of kenaf stems showed that they can be viably utilized as substitute for wood flour fillers. Manufacturing tests conducted at the U.S. Forest Products laboratory showed that kenaf stems can be used as filler in virgin plastics to yield impact properties similar to wood-filled composites. Ultimate mechanical and dimensional stabtity test conducted at the University of Illinois showed that virgin plastics filled with 40% kenaf fibers are the most promising blends. The flexural properties of the resulting products were higher or within the range of extruded and injection molded grades that use commercial resins and wood flours. The deficiency of the kenaf-based composites was the low tensile strength which suggests that they should not be utilized in systems requiring high tensile property.

This study had met most of its initial goals of discovering commercial uses of kenaf fibers in Illinois. Kenaf stems fibers are very feasible alternatives to wood fibers and could be utilized to reduce the cost of producing traditional thermoplastic composites. Recyclable and environmental-friendly products could be produced from kenaf fibers with potential used in industries like the container and the automotive industry.

INTRODUCTION

The purpose of the study was to determine baseline data for the use of whole stalk kenaf as a low cost reinforcing filler in plastics. The plastics industry already uses a wide variety of fillers for plastics, and direct comparisons wilI be made to these commercial fillers and other natural fiber fillers.

MATERIALS

To make the comparison to commercially derived fillers, virgin polypropylene (PP) was used. The PP is Fortilenneâ HB 3907, an injection moldmg grade homopolymer with a melt flow index of 44 g/10min. The results from this study can be directly compared to those results report in Wood and Mineral Fillers for Injection Molding Grade Polypropylene.[1] The fillers were also used with recycled Low-Density Polyethylene (LDPE) to show how these fillers can be used with a low-cost widely available recycled plastic. The LDPE selected came from mixed post-consumer film waste, such as grocery bags and shrink wrap, and has a melt flow index of 5 g/10 min. LDPE is often used in recycled plastic products such as plastic lumber, curb stops, and drainage pipes. The LDPE used is a post-consumer mixed film waste.

The kenaf stalks were harvested from the experimental plots at University of Illinois. The material was hammermilled and screened to -35 mesh which is almost equivalent to a common grade of commercial wood flour fillers. The abbreviations for the materials used are reported in Table 1.

PROCESSING

The materials were compounded at the U.S. Forest Products Laboratory (FPL) using a Davis Standard (Pawcatuck, CT) 32 mm twin screw extruder at 40% by weight filler. The compounded materials were then pelletized and dried at 105° C for 24 hours before being injection molded. The materials were molded at both 40% and 20% by weight filler into standard ASTM test specimens in a 33-ton Cincinnati Milacron (Batavia, Ohio). The conditions for which the material was extruded and molded are attached.

There were some problems with the injection molder. All of the blends at 40% fillers content were compounded with such a low bulk density that they created a bridge at the feed throat had to be pushed into the feed throat by hand. This was an inconvenience, but did not affect the final product. The problem could be eliminated in the future by compounding more dense pellets. The system of PP filled at a content of 40% kenaf occasionally clogged the nozzle of the injection molder. However, a sufficient number of samples were molded before the nozzle clogged.

The chosen PE also accounts for some molding problems. The PE has such a low melt flow,

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[1] English, Brent, Nicole Stark, and Craig Clemens, “Wood and Mineral Fillers for Injection Molding Grade Polypropylene” USDA Forest Service, November 1996.

that in order to completely fill the mold, the injection pressures must be increased. However, the PE/K blends molded up with little problem.

TESTING

Melt index and impact testing, tensile properties, and flexural properties were determined. The data for the impact testing are reported in Table 2. The values listed are average values for five samples. The individual data for each sample is attached. The data for the melt flow index values are also reported in Table 2. In each case, the melt flow data was taken at 190° C. Attached to Table 2 are some literature values for PP filled with several other fillers[2]. In this table, the material is reported with the polymer type fist the percent by weight filler, and then the filler type. For the comparison values, PI is a 40 mesh ponderosa pine wood flour that is commercially prepared, DW is a demolition wood fiber that comes from post consumer sources and screened to 40 mesh, TA is talc, FG is fiberglass, and CC is calcium.

The notched impact energy for PP filled with kenaf (K) is a just little higher than the energy for PP filled with PI or DW. The unotched impact energy for PP filled with K is similar to the energy when filled with PI or DW. The melt flow index for PP filled with PI or DW appears to be higher than the melt index for PP filled with kenaf (K).

Table 3 presents the bending and tensile properties of standard blend using traditional wood flour and compared with those found in this study using kenaffibers and PP and PE. The most promising blend found in this study is that composite filled with 40% kenaf and mixed with polypropylene (virgin plastic) are comparable with the established standards. The performance of kenaf fibers in terms of flexural strength and modulus, and tensile strength are in between the range of extrusion and injection molding grades of wood flour fillers. Kenaf blended with recycled plastics (PE or Low-Density Polyethylene) does not appear feasible in terms of mechanical properties.

CONCLUSION

Kenaf can be used as a filler in a high melt flow, virgin polypropylene to yield impact properties similar to those found in systems filled with pine and demolition wood. Kenaf may also be used in a low melt flow, recycled low-density polyethylene to yield high impact energies. Polymer selection plays a large role in the properties of a filled polymer system, as well as feasibility with certain fillers. A higher melt flow PE may improve the melt characteristics greatly. In the future it would be wise to determine the thermal degradation temperature a filler before the extrusion and molding is carried out. In this study, all blends of 40% kenaf (PP-40-K) polypropylene with virgin plastic (PP) yielded the best overall strength performance. Except the

[2] English, Brent, Nicole Stark and Craig Clemens, "Wood and Mineral Fillers for Injection Molding Grade Polypropylene" USDA Forest Service, November 1996.

tensile strength, the blends demonstrated higher peformance in flexural properties. Recycled plastic or polyethylene filled with 40% kenaf (PE-40-K) had the worst properties.

Table 1. Formulations and a list of the abbreviations representing the materials used in this study.

Plastic		Filler	
PP (Polypropylene)	60%	(K) Kenaf	40%
PP (Polypropylene)	80%	(K) Kenaf	20%
PE (Low density Polyethylene- Recycled bags)	60%	(K) Kenaf	40%
PE (Low density Polyethylene- Recycled bags)	80%	(K) Kenaf	20%

Table 2. Izod Impact and Melt Flow Indices for kenaf (K) combined with PP or PE and compared to reported literature values.

Material	Notched Impact (J/m)	Unotched Impact (J/m))	Melt Flow Index (g/10 min)
PP-20-K	18	115	4.3
PP-40-K	23	69	1.7
PE-20-K	15[a]	—[b]	1.8
PE-40-K	124	213	0.6
PP-20-PI	13	110	8.6
PP-40-PI	16	60	1.9
PP-20-DW	12	130	7.8
PP-40-DW	13	80	2.9
PP-40-CC	19	470	15.1
PP-40-TA	17	115	12.2
PP-40-FG	17	90	9.6
PP	17	540	16.5

[a] Indicates that the material did not break through resulting in a hinged specimen.
[b] Indicates that the material did not break at all.

Table 3. Comparison of mechanical properties of selected molded kenaf, fibers with standard blends using wood flour.

	Bending		Tension
BLENDS	Flexural Strength (psi)	Flexural Modulus (psi)	Tensile Strength (psi)
PP-40-K	6,727	332,800	3,639
PP-20-K	6,572	248,500	4,100
PE-40-K	1,972	91,200	1,110
PP-WF-X	8,947	588,700	4,307
PE-WF-X	2,857	390,050	5,191
PP-WF-I	3,915	423,400	7,526
PE-WF-I	2,712	352,350	4,698

WF = wood flour X = extrusion grade (40% filler) I = injection molding grade (30% filler)