EFFECT OF CONFIGURATION AND SOME PROCESSING VARIABLES ON THE PROPERTIES OF WOOD FIBER-POLYETHYLENE COMPOSITES

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[ABSTRACT] Chemical compositions and fiber measurement of virgin and recycled fibers from three sources were determined. Results revealed that virgin southern pine fiber had highest alcohol-benzene extractive and lignin contents and lowest holo- and alpha-cellulose content among the three fiber types. Fiber length distribution of virgin fiber was less sensitive to disintegration. Effects of recycled fiber, panel configuration, and some processing variables on the performance of wood fiber-polyethylene composites were also studied. Investigation showed that replacing virgin fiber with recycled fiber adversely affected mechanical properties of fiberboard. In both homogenous and layered configurations with 20% polyethylene content, IB, MOR,, MOE,,, and dimensional stability were directly related to virgin fiber ratio. However, layered structure with 40% polyethylene showed improvement in dimensional stability. Experimental results also indicated that, at given composition, i.e., virgin fiber:recycled fiber:polyethylene=40:40:20, panel IB was affected by both hot press temperature and panel density; bending properties and water absorption were altered by panel density.

1. INTRODUCTION

Vast quantities of fiber and wood wastes, both commercially and residentially,, are generated in the United States each year. McKeever and coworkers [14, 15] identified three major sources of wood waste in the United States as municipal solid waste (MSW), new construction and demolition waste, and primary timber processing mill residues. Among the estimated 188 million tons of MSW generated in 1993, the amount of wood waste, paper and paperboard, and yard trimmings comprised respectively 7%, 38%, and 16% of the total volume. On the other hand, a total of 28.8 million tons of new construction and demolition waste and 100.5 million tons of primary timber process g mill residues were genera&d in 1993.

Tremendous efforts have been endeavored to reuse these materials. One way to reutilize usable cellulosic materials from waste stream is to make panel products that comprise solely recycled fibers or mixtures of recycled and virgin fibers [2, 8, 9, 16, 17]. Another alternative is to combine them with nonwood materials and make composite products [4, 18, 26, 28]. Wood flour has been used as filler and reinforcing material in the plastic industry. It is therefore technically viable to incorporate these hvo components to make composites,

Melt-blending and air-forming are two major methods to fabricate composites including wood-plastic composites. Numerous studies have focused on developing and improving the properties of melt-blended wood-plastic composites [6, 10, 11, 12, 19, 20, 25]. The overall results of these studies showed that with appropriate surface modification and proper processing conditions, wood fibers can serve as satisfactory fillers in thermoplastic materials, resulting in enhanced stiffness, comparable strength properties and, most of all, lower cost.

Wood fiber-filled thermoplastics have promising features which can be tailored to a broad spectrum of applications [28]. However, fiber deterioration induced t repeated kneading and blending at elevated temperatures is one of the major drawbacks of melt-blended composites. Moreover, melt-blending requires special machinery to fabricate the products and the maximum fiber loading is generally restricted. If recycled wood waste and plastics can be incorporated in conventional wood composites without significant reduction in strength properties, the resulting wood fiber-plastic composites can serve as low-cost substitutes for conventional wood composites. Wu et al. [27] fabricated an air-laid panel product which resulted in improved dimensional stability without using special machinery.

Air-forming methods may, therefore, solve the problem from the other end.

This study was undertaken to optimize the processing factors of air-laid wood fiber-plastic composites with structured experiment designs. This paper reports a series of interrelated experiments that involved fou. purposes: (1) characterization of wood fibers from three sources, (2) investigation on effect of recycled fiber on the propenies of hardboards, (3) enhancement of properties of wood fiber-polyethylene composites by various panel configurations, and (4) determination of the effect of some processing variables on properties of wood fiber-polyethylene composites.

2. MATERIALS AND METHODS

Materials

The three types of fibers characterized were: (1) OCC ∞ Old corrugated cardboard from local recycle industry, (2) ROP ∞ Recycled office paper (mainly waste Xerox paper), and (3) VIR ∞ Southern pine virgin fibers from ' fiberboard manufacturing. VIR and OCC were also used to fabricated hardboards and wood fiber-polyethylene composites. Urea formaldehyde, supplied by Neste Co. (Chembond UF), with 65% solid content, pH 8.0, was used as the binder. The polyethylene (PE) plastic was obtained from commercial garbage bags (about 0.2 mm in thickness). These bags were shredded into squares approximately 2.54x2.54 -cm with a paper cutter and were then ground to powder using a conventional disk refiner. The resulting size distributions of PE powder were 1.6%, 30.7%, 21.2%, 18.2%, and 28.3% for 18, 45, 60, 80, and >80 mesh, respectively.

Experimental design

Fiber composition
A completely randomized design was employed to examine the effect of recycled fibers on the properties of southern pine hardboard. The amounts of recycled fibers added were 0%(A), 20%(B), 40%(C), 60%(D), 80%(E), and 100%(F) by weight A total of 18 panels were fabricated, with 3 replicates in each fiber level

Panel configuration
Five confip ation schemes of wood fiber-polyethylene composite containing virgin fiber, recycled fiber, and recycled poly hy ne were employed. Among the five schemes, three were homogeneous (G, H, and I) and two were layered structures (J and K). The VIR:OCC:PE ratios for schemes G, H, I, J, and K were 80:0:20, 0:80:20, 40:40:20, 60:40:0, and 40:40:20, respectively. For the layered schemes, panels were fabricated in a manner that each of the face layer was composed of VIR with its weight 10% to the total panel weight and the core layer was composed of the mixture of remainders. Each scheme contained four panels in a completely randomized design.

Processing variable
Panels with fixed VIR:OCC:PE=40:40:20 composition were fabricated to investigate effects of nominal panel density (PD), hot press temperature (TEMP), and hot press time (TIME) on the properties of wood fiber. polyethylene composites. A completely randomized design with 2x3x2 factorial treatment arrangement was adopted, and a three-way analysis of variance (ANOVA) was performed to evaluate the effects of processing variabks. Levels for each variables were 0.96 and 0.80 g/cm³ for PD, 177,204, and 232°C for TEMP, and 5 and 7.5 min. for TIME. Each treatment combination contained three replicates.

Methods

Chemical composition
Determination of chemical compositions of the three fiber sources was conformed to ASTM standards, namely: alcohol-benzene extractive content (ASTM D 1105-84), holocellulose content (ASTM D 1104-56), alpha-cellulose content (ASTM D 1103-60), and Klason lignin content (D 1106-84)[1], with replications of 24, 12, 6, and 6, respectively, in a completely randomized design.

Fiber length distribution
From each of the three fiber sources, fifteen 70 g dry fiber samples were collected. Each of these samples was saturated in 2500 ml water overnight and then subjected to disintegration using a disintegrator (Hermann Manufacturing Co., rpm∞120). The five levels of disintegration used were 100, 200, 300, 400, and 500 revolutions, each of them contained three replicates. Three 20 g subsamples were later randomly extracted from each sample and were placed in a water classifier ('The Bauer Bros. Co.), which divided the fibers into four fractions of various mesh screens, i.e., 14, 28, 48, and 80. Fiber length distributions of the three fiber sources at five disintegrating revolutions were determined by measuring the ovendrkd weight proportions of the four fractions.

Panel fabrication
Panels were fabricated with target density of 0.80 g/cm³ and nominal dimensions of 30x30x0.6 -cm. To achieve better fiber distribution, the two fiber types, VIR and OCC, were hand-mixed first, then hand-mixed with PE if necessary. The mixtures were blended with UF resin (10% by weight) in a laboratory-scaled propeller glue spreader and then randomly air-laid in an automatic air-forming system Furnishes were compressed in a hot press for 5 minutes. In the investigation of the processing variable effects, panels with the same nominal dimensions were fabricated under processing conditions designated by the experiment design.

Mechanical testing
Properties examined include (1) Internal bond (IB), (2) 3-point bending modulus of rupture (MOR$_b$) and bending modulus of elasticity (MOE$_b$), (3) water absorption after 2 (WA2) and 24 hours (WA24), and (4) thickness swelling after 2 (TS2) and 24 hours (TS24). All the strength

property test procedures were performed in accordance with ASTM D-1037-94 [1]. Two specimens were extracted from each panel for bending test., 3 for IB, and 1 for both WA and TS.

3. RESULTS AND DISCUSSION

Fiber characterization

The contents of alcohol-benzene extractive, holocellulose, alpha-cellulose, and lignin in wood fibers from the three different sources are summarized in Table 1. Results of Turkey's tests among the three fiber types for each chemical component are also presented. Alcohol-benzene extractive and lignin contents showed the same ranking with respect to the three fiber types. Virgin fibers (VIR) had the highest contents of alcohol-benzene extractive and lignin, followed by old corrugated cardboard (OCC), and then recycled office paper (ROP). The rankings for holo- and alpha-cellulose contents were the reverse of those of alcohol-benzene extractive content and lignin content.

The average contents of alcohol-benzene extractive, holo-cellulose, and lignin in VIR are comparable to the results reported by Shupe [22]. The lowest holo- and alpha-cellulose contents and highest extractive and lignin contents in virgin fiber is due to VIR is from thermomechanical pulp. Whereas the opposite trends found in ROP is because Xerox paper is mostly made of bleached softwood kraft pulp. On the other hand, OCC, generally made of unbleached kraft pulp as the liner. board and mixed hardwood semichemical pulp as the corrugating medium [7], is situated in between. The differences in chemical compositions clearly reflect the preceding pulping processes the three fiber types received.

Table 1. Chemical Compositions for three fiber types.

Chemical composition	OCC	ROP	VIR
Alcohol-benzene extractive content (%)	3.7 B^2 (0.9)'	0.4 c (0.3)	5.9 A (1.1)
Holo-cellulose content (%)	81.8 B (0.6)	82.8 A (0.4)	71.3 C (1.4)
Alpha-cellulose content (%)	75.5 B (0.5)	00.1 A (1.0)	61.5 C (1.0)
Lignin content (%)	16.0 B (0.4)	0.7 C (0.1)	27.6 A (0.4)

^{1}. Numbers in the parentheses are standard deviations.
^{2}. Mean values followed by different letters are statistically different at u-0.03.

Figure 1 shows the dependence Of fraction On number of disintegrating revolutions for the three fiber types. The three fiber types examined showed different patterns. In VIR, 14-mesh class remained the dominating fraction for all disintegrating revolutions. However, fraction for each of the four classes was the same with respect to number of revolutions, indicating the fiber length distribution of VIR was relatively

unaffected by disintegration. In both OCC and ROP, 14-mesh class was the major fraction at lower disintegrating revolutions. As the number of revolutions increased, 28-mesh class became more prominent. These patterns indicate that virgin fibers and recycled fibers behaved differently to disintegration. Recycled fibers were less resistant to disintegration than virgin fibers.

Effect of recycled fiber on the properties of hardboards

Table 2 shows the physical properties, mechanical properties, and dimensional stability of hardboard made from different compositions of virgin fiber and recycled fiber. The average moisture content for all panels ranged from 4.5 to 5.5%. The values in the table indicate that adding recycled OCC fiber adversely affected physical and mechanical properties of hardboard.

Figure 2 shows the effects of virgin fiber ratio on mechanical properties of hardboard. The relationship between virgin fiber ratio and IB was parabolic, whereas bending properties were linearly dependent on virgin fiber ratio. Virgin fiber ratio contributed approximately 95%, 74%, and 72% of the variations in the IB, MOR$_b$, and MOE, of fiberboard. The reasons for these adverse effects of recycled fibers was due to variations in panel density and inferiority in individual strength properties of recycled fiber. In addition, the finer recycled fibers may increase the surface area which results in lower resin content per unit surface area, and the more hydrophilic recycled fibers may also induce over-penetration of adhesive. In comparison with panel A (100% VIR), panel F (100% OCC) showed 83% lower IB, and 77% and 67% lower MOR$_b$ and MOE$_b$, respectively. This implies that the impact of recycled fibers is more drastic in IB than in bending properties. The slopes shown in figure 2 also reveals that the reduction in MOR$_b$ is higher than in MO&,. The LB, however, can be improved by adding more adhesives [9, 16].

The effects of virgin fiber ratio on dimensional stability of fiberboards are presented in Figure 3. In both WA2 and WA24 water absorptions, 89% of the variations were attributed to virgin fiber ratio. The slopes of these two lines were slightly different (-0.6451 vs -0.5778), showing that the effect of fiber composition was slightly stronger on WA 2 than on WA24. The 2-hour (TS2) and 24-hour (TS24) thickness swellings of fiberboard were highly dependent on virgin fiber ratio, with coefficients of determination measured Up to 0.95 and 0.94. The dependence of dimensional stability on virgin fiber ratio can be explained from physical, chemical, and anatomical aspects. Physically, the average fiber length of OCC is considerably shorter than that of VIR; chemically, OCC has higher holocellulose content and lower lignin content than VIR; and anatomically recycled OCC fibers are "fuzzier" than VIR fibers, which result in more exposures of absorption site on fiber surfaces.
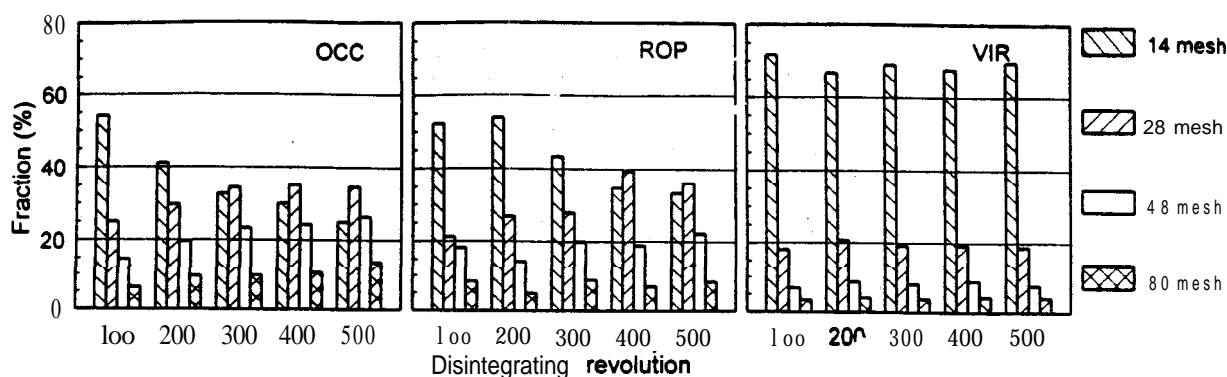
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Figure 1. Fraction of each mesh class for the three fiber types at various disintegrating revolutions.

Table 2. Physical properties, mechanical properties, and dimensional stability of fiberboards made from various fiber compositions.

Treatment	A	B	C	D	E	F
VIR ratio	100%	80%	60%	40%	20%	0%
MC	4.57	4.68	5.27	5.44	5.41	5.40
(%)	(0.36)'	(0.11)	(0.17)	(0.24)	(0.05)	(0.07)
Density	0.77	0.74	0.75	0.73	0.70	0.69
(g/cm³)	(0.02)	(0.03)	(0.02)	(0.02)	(0.04)	(0.02)
IB	0.90	0.58	0.49	0.30	0.24	0.15
(MPa)	(0.05)	(0.10)	(0.96)	(0.03)	(0.01)	(0.01)
MORb	31.3	20.9	18.9	13.6	9.6	7.2
(MPa)	(11.1)	(3.8)	(2.1)	(2.4)	(2.7)	(0.9)
MOEb	2827	2145	2076	1428	1221	931
(MPa)	(903)	(366)	(276)	(393)	(262)	(13 1)
WA2	75.0	89.4	95.5	1092	127.9	139.6
(%)	(9.2)	(9.3)	(6.7)	(5.6)	(13.0)	(6.5)
WA24	87.6	102.3	105.7	117.0	135.7	146.2.
(%)	(5.8)	(6.5)	(6.0)	(4.9)	(13.0)	(6.4)
TS2	21.7	24.9	26.9	29.8	32.7	35.6
(%)	(2.8)	(1.1)	(0.6)	(0.9)	(1.0)	(0.6)
TS24	25.0	27.6	29.3	32.6	35.9	38.8
%)	(2.0)	(0.7)	(0.5)	(0.9)	(1.6)	(0.2)

[1.] Numbers in parentheses are standard deviations.

Effect of configuration on the properties of wood fiber-polyethylene composites

Mechanical properties and dimensional stability of w d fiber-polyethylene composites With various configurations are illustrated Figures 4-5. Average moisture contents for the five configurations ranged from 3.9 to 4.5%, and panel densities ranged from 0.66 to 0.72 g/cm³. Results of Tukey's test (Figures 4-5) showed a general trend for all strength properties in the 5 schemes: homogeneous configurations followed G>I>H pattern. The layered structures were undistinguishable between I and H while significantly lower than G. In dimensional stability, WA2, WA24, TS2, and TS24 also shared a similar trend from high to low: J - H - (K or I) - G. The implications are as follows:

(1) At given PE content (20%) and homogeneous configuration (G vs H vs I), mechanical properties and dimensional stability were related to virgin fiber ratio,

(2) For the same material composition (I vs K), homogeneous or layered structure did not affect mechanical properties and dimensional stability,

(3) Within the same layered structure (J vs K), replacing 20% virgin fiber with PE did not significantly decrease IB, MORb and MOE,, of fiberboard, but greatly improved dimensional stability of fiberboard.

The influence of adding recycled PE can be evaluated by comparing scheme G with treatments A and B. The IB, MORb and MOE, of G were lower than those in A but slightly higher than those in B (except MOEb). These values also indicate that the impact of adding PE was more serious in MORb and MOEb than in IB. Replacing 20% of recycled fiber with PE (scheme H vs. treatment F) showed an improvement in IB (0.48 vs 0.15 MPa) and MORb (9.2 vs 7.2 MPa). In. contrast to homogeneous configuration, the layered structure with 10% virgin fiber on each face was less sensitive to the addition of PE; i.e., when 20% virgin fiber was replaced with PE, scheme K had comparable strength properties as scheme J.

As mentioned previously, increasing the amount of recycled fiber leads to inferior dimensional stability. In the three-component (VIR-OCC-PE) system, the analogous trend still held Within the two-component system, replacing hydrophilic fibrous material with hydrophobic PE (A vs G and F vs I-I) improved dimensional stability. Moreover, panels without PE (scheme J) showed the lowest dimensional stability. The reasons or this may be due to the contribution of hydrophobic PE which blocks the voids inside panel, resulting in reduction of water uptake and restraint in thickness swelling. Moreover, poor wettability of PE leads to excess adhesive available for wood fibers, which enhances the bonding property and hence the dimensional stability of the resulting panels.

Effect of processing variables on the properties of wood fiber-polyethylene composites

Table 3 reports the mechanical properties and dimensional stability for wood fiber-polyethylene composites fabricated
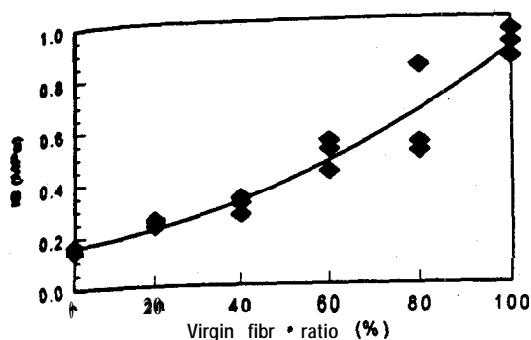
Figure 2. E..ects of virgin fiber ratio on mechanical properties of fiberboard.

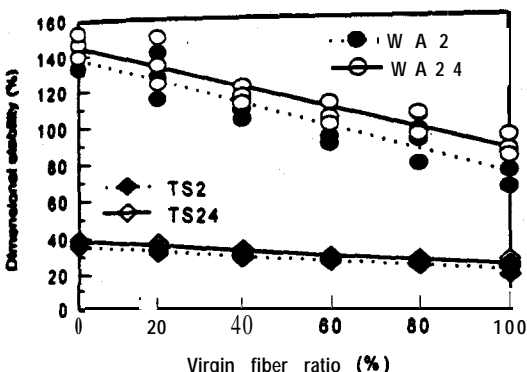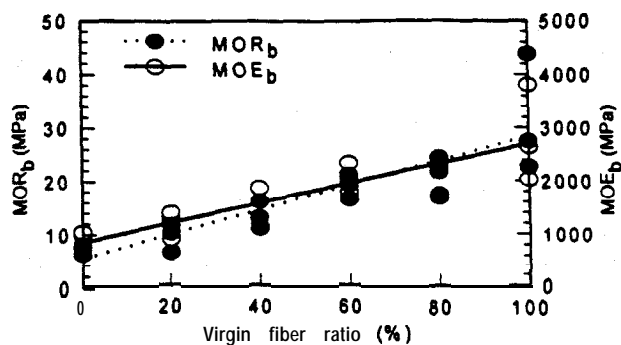Figure 3. Effect of virgin fiber ratio on dimensional stability of fiberboard.

Figure 7. Effect of panel density on water absorption of wood fiber-polyethylene composites

at various processing conditions. The average moisture optenofbrslltteatmentcombinationswerebetween2.3 and 5.2%, and the actual panel densities were somewhat lower than the nominal density.

A three-way ANOVA detected TEMP and PD main effects, but did not reveal any interaction. Figure 6 shows that IB was affected by both TEMP and PD. IB was higher at lower TEMP and higher PD. Wood constituents are susceptible to thermal decomposition at elevated temperatures [13, 23, 24], hence thermal deterioration may be responsible for the drop in IB. In addition, under the influence of fiber geometry, fibers tend to lay horizontally during mat-forming, resulting in parallel-to-panel-surface fiber orientation in the panels. Consequently, IB not only indicates bonding strength between fiber and resin, but also reflects tensile strength perpendicular to fibers and fiber bundles. The reduction in IB may also be due to: (1) the presence of microfissures, which initiated wood failure during tensile tests, (2) the degradation of adhesive at elevated temperatures, and (3) the precure of adhesive before density profile develops On the other hand, the increase in IB with density is reasonable, because at a given wood density, increasing panel density results in higher compaction ratio, which in turn enhances panel strength properties. Figure 6 also shows that both MOR and MOE, were only affected by PD) and not by TEMP and TIME. Generally, the strength properties of wood are reduced as a result of interactions of temperature-time-moisture content in the air [5, 21,23]. However, Stamm

[23] reported that the lost of MOR, during a 5-day period. at 200°F under atmospheric condition was merely about. 0.5% for softwoods, and even less for hardwoods. Moreover, due to the intrinsic viscoelastic nature of wood, deformation in tensile perpendicular to panel surface is less than those of bending and compression. Therefore, at elevated temperatures for as long as '7.5 min, the influences of temperature and time were more pronounced on IB. than on bending properties of hardboard.

In dimensional stability, both WA2 and WA24 were affected by PD. The effects of panel density on WA2 and WA24 are shown in Figure 7. Low density wood fiber-polyethylene composites tended to retain more water in immersion test This phenomenon is reasonable since low density panels have more voids which provide extra space to hold the absorbed water. However, it is not unusual for high density conventional parti_boards to exhibit high thickness swelling [13]. Contrary to WA, effects of PD on the TS of wood fiber-polyethylene composites was not significant. The reasons may be due to: (1) the volumetric ratio of hydrophilic wood fiber is much smaller than in conventional hardboard, (2) PE blocks the sorption sites of wood fiber, and (3) hydrophobic PE facilitates greater restraining force to offset the hygroscopic expansion of wood fiber. Results also indicated that dimensional stability of wood fiber-polyethylene composites was unaffected by hot press temperature and time.
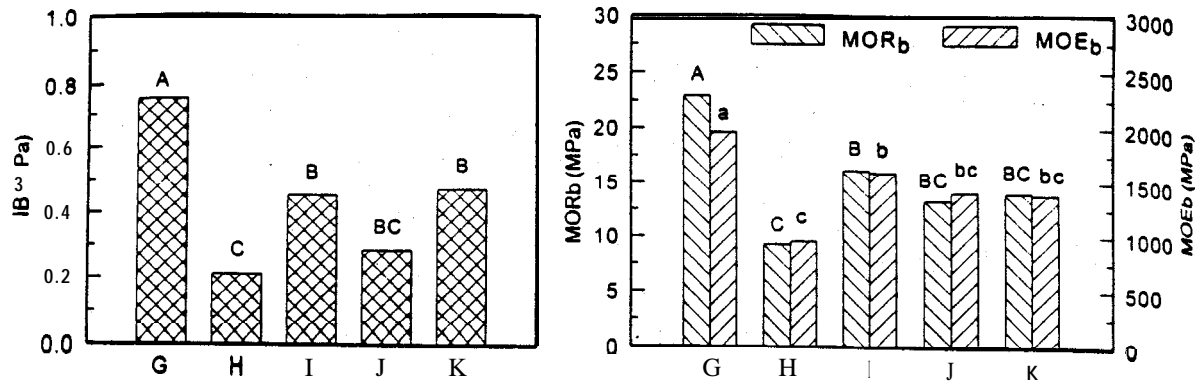
Figure 4. Mechanical properties for wood-fiber polyethylene composites with various configurations,
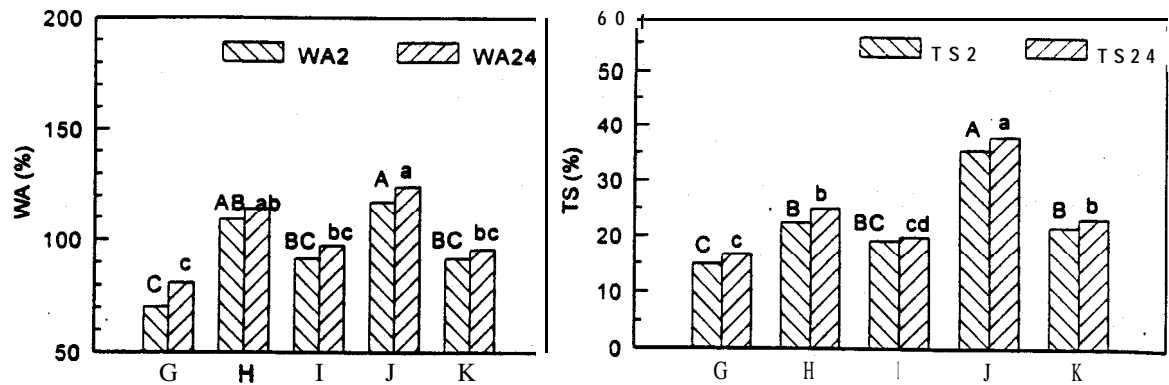

Figure 5. Dimensional stability for wood fiber-polyethylene composites with various configurations.

Table 3. Physical properties, mechanical properties, and dimensional stability of wood fiber-polyethylene composites with VIR:OCC:PE=40:40:20 at various processing conditions.

TEMP'	177	177	177	177	204	204	204	204	232	232	232	232
PD'	0.8	0.96	0.8	0.96	0.8	0.96	0.8	0.96	0.8	0.96	0.8	0.96
TIME'	5	5	7.5	7.5	5	5	7.5	7.5	5	5	7.5	7.5
MC (%)	5.22	4.06	3.92	3.36	3.79	3.34	3.11	2.38	3.28	2.91	3.24	3.35
	(0.38)'	(0.27)	(0.11)	(0.07)	(0.27)	(0.21)	(0.38)	(0.20)	(0.21)	(0.10)	(0.09)	(0.52)
Density (g/cm³)	0.78	0.85	0.76	0.88	0.78	0.90	0.81	0.92	0.74	0.87	0.79	0.92
	(0.04)	(0.03)	(0.03)	(0.01)	(0.04)	(0.05)	(0.07).	(0.03)	(0.05)	(0.02)	(0.03)	(0.02)
IB (MPa)	0.47	0.71	0.59	0.64	0.39	0.52	0.35	0.53	0.39	0.54	0.33	0.57
	(0.00)	(0.05)	(0.14)	(0.15)	(0.08)	(0.04)	90.04)	(0.01)	(0.03)	(0.08)	(0.03)	(0.04)
MORb (MPa)	15.32	20.82	11.17	26.62	13.26	24.81	14.48	28.84	18.36	25.93	14.63	23.32
	(2.88)	(5.75)	(2.06)	(8.83)	(1.88)	(6.23)	(2.89)	(5.37)	(2.98)	(0.44)	(0.75)	(1.01)
MOEb (MPa)	1572	2069	1248	2531	1372	2352	1476	3021	1917	2779	1648	2779
	(345)	(524)	(207)	(931)	(138)	(545)	(352)	(517)	(317)	(131)	(76)	(172)
WA2 (%)	68.6	55.0	70.6	45.2	67.4	43.2	59.9	40.8	13.7	53.3	60.2	41.4
	(8.4)	(5.3)	(8.4)	(5.2)	(9.9)	(9.3)	(16.3)	(8.9)	(14.4)	(2.2)	(5.7)	(8.7)
WA24 (%)	75.8	60.4	76.41	54.34	72.14	52.1	67.41	49.9	78.5	57.5	66.9	50.5
	(8.0)	(4.9)	(7.5)	(4.1)	(9.5)	(7.3)	(14.1)	(5.3)	(13.7)	(2.2)	(3.4)	(3.5)
TS2 (%)	18.2	17.6	17.0	16.6	16.9	15.2	16.6.	16.4	16.5	16.7	15.5	15.9
	(0.9)	(1.0)	(0.6)	(1.4)	(1.0)	(1.6)	(0.5)	(1.1)	(1.8)	(1.1)	(0.3)	(2.3)
TS24 (%)	18.7	18.6	17.8	18.1	17.7	17.3	18.4	19.0	17.8	18.2	16.9	18.8
	(0.5)	(0.7)	(0.4)	(1.0)	(1.4)	(0.4)	(0.1)	(0.2)	(2.0)	(1.0)	(0.5)	(1.5)

[1]. TEMP, PD, TIME denote hot press temperature ("C), nominal panel density (kg/cm³), and hot press time (min), respectively

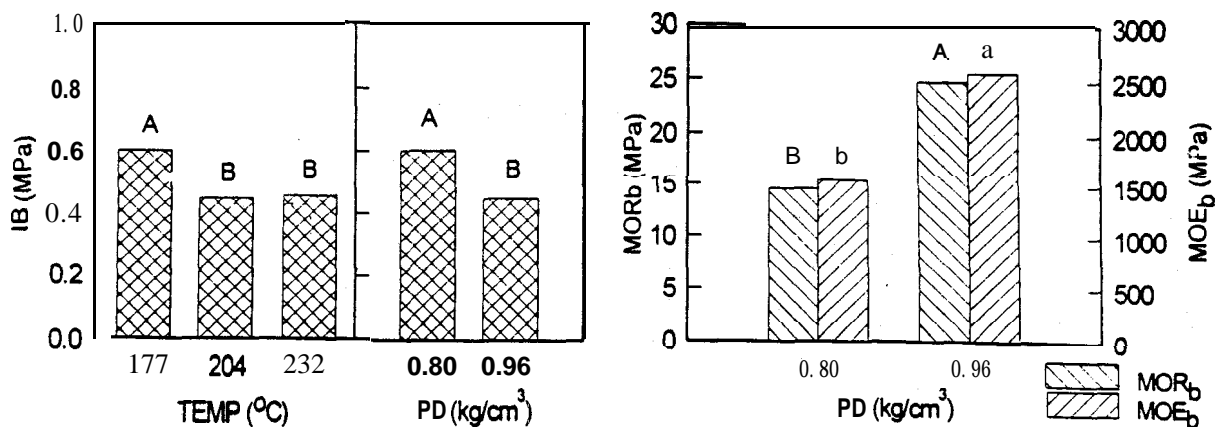[2.] Numbers in parentheses are standard deviations.

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Figure 6. Effects of hot press temperature and panel density on mechanical properties of wood fiber-polyethylene composites

4. CONCLUSIONS

Studies on chemical compositions **and** fiber measurement of virgin and recycled fibers from three sources showed significant differences among fiber types. Virgin southern pine fibers had the highest alcohol-benzene extractive and lignin contents and lowest holo- and alpha-cellulose contents. Whereas recycled office paper exhibited the lowest extractive and lignin contents and highest holo- and alpha-cellulose. contents. Recycled office paper and old corrugated cardboard were rather sensitive to disintegration, which resulted in the shift of fiber length distribution. Virgin fiber, on the other hand, was unaffected by disintegration.

  Replacing virgin fiber with recycled fiber adversely **affected** mechanical properties of fiberboard. Bending properties **and** dimensional stability were linearly dependent on virgin fiber ratios. At least 70% of the variations in these properties was attributed to fiber composition. Internal bond strength showed polynomial relationship with virgin fiber ratio. As high as 95% of the variations in fiberboard IB can be explained by fiber composition.

  Five schemes were **devised to investigate the** effects of panel configuration and polyethylene filler on the properties of wood fiber-polyethylene composites. With **fixed** polyethylene content (20%) **and** homogeneous configuration, IB, MOR$_b$, MOE, and dimensional stability were directly related to virgin fiber ratio. Layered structure **showed** similar strength properties and dimensional stability with homogeneous configuration. However, using layered structure **with** 40% recycled fibers, reducing the virgin fiber ratio from 60 to 40% by substituting 20% polyethylene, did not **affect** panel strength properties, but appreciably increased dimensional stability.

  Three levels of hot press temperature, two levels of panel density, and two levels of hot press time Were formulated to examine the responses in strength Properties **and** dimensional stability of wood fiber-Polyethylene composites. Experimental results indicated that, at given composition, i.e., virgin fiber :

recycled fiber : polyethylene=40:40:20, internal bond strength was affected by both hot press temperature and panel density; whereas bending properties **and** water absorption were altered by panel density. Thickness swelling, however, was unaffected. Taking into account all the properties tested, the most appropriate processing conditions for wood fiber-polyethylene composites with 40:40:20 composition was hot pressing at 177°C for 5 min. with panel density of 0.96 g/cm^3.

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