NOTE

Studies on the Physical Properties of Some Cellulosic Fibers

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INTRODUCTION

Natural fibers from plant sources feature a wide range of physicochemical properties, some of which are dependent on the nature of the plants and on the parts from which the fibers are derived.[1–4] Furthermore, the properties of fibers are greatly influenced by the configurational characteristics of their molecules. For example, vegetable fibers have spiral molecules that are highly parallel to one another, and for some fibers such as flax, ramie, and hemp, the spiral angles are low, accounting for their high strength and low extensibility.[1,2] In addition, fiber density is believed to be closely related to the mechanical properties, moisture absorption, homogeneity, and degree of order of the fiber.[5]

Cellulosic fibers have a wide range of industrial application in their native forms and in the modified forms, such as rubber-cellulose fiber composites.[6,7] In a previous report,[8] it was shown that some bast fibers from unconventional sources may have industrial applications, based on their physicochemical properties, which were largely comparable to those of the conventional ones. The present report is an extension of these studies to include other less well-known bast fibers from a variety of plants, some of which grow as shrubs and are cultivatable, namely, *Avaria chamae, Corchorus olitorius, Corchorus tridens, Fiscus thonningii, Grewia mollis, Hibiscus miranthus,* and *Hibiscus rostellatus.* Their physical properties are reported and discussed.

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EXPERIMENTAL

A 250-g sample of the fibers was delignified in 200 mL solution of 16% NaOH and 2 g urea in an autoclave at 120°C for 2 h. The tensile properties of the fibers were determined at ambient temperature (30°C), using Instron Model 220 D testing machine at crosshead speed of 3 mm min^{-1} and gauge length of 25 mm. The sample length was 50 mm, and the average of five determinations was taken for each sample. Other parameters, that is, moisture content, ash and fiber density, were determined by standard methods.[9–11]

RESULTS AND DISCUSSION

The initial moduli of the fibers at ambient temperatures (Table I) are not higher than 0.82 ± 0.10 $Ntex^{-1}$. Compared to the values for other fibers,[1] namely flax (18.0 $Ntex^{-1}$) and jute (17.2 $Ntex^{-1}$), they are lower by as much as two orders of magnitude. The stress-strain curves are characterized by crimp, whose values are up to 3.96 ± 1.62% for *H. rostellatus* at ambient temperature.

The specific work of rupture for *C. olitorius, C. tridens,* and *H. rostellatus* at ambient temperature are lower than the values for some conventional bast fibers, namely jute (2.7 $mNtex^{-1}$) and hemp (5.3 $mNtex^{-1}$), by as much as a factor of four. For the other fibers, the values are significantly lower, by as much as an order of magnitude, as in the case of *G. mollis* (0.29 ± 0.10 $mNtex^{-1}$).

The tenacity for the fibers is not higher than 41.84 $mNtex^{-1}$, the value for *C. olitorius*. They are compara-

Table I Tensile Properties of Fibers

Parameter	*Avaria chamae*	*Corchorus olitorius*	*Corchorus tridens*	*Fiscus thonningii*	*Grewia mollis*	*Hibiscus miranthus*	*Hibiscus rostellatus*
Initial modulus ($mNtex^{-1}$)	0.32 ± 0.16	0.82 ± 0.10	0.76 ± 0.26	0.62 ±0.22	0.62 ± 0.38	0.64 ±0.35	0.59 ±0.17
Specific work of rupture ($mNtex^{-1}$)	0.38 ± 0.09	1.58 ± 0.23	1.34 ±0.32	0.67 ± 0.29	0.29 ± 0.10	0.31 ± 0.13	1.65 ± 0.89
Tenacity ($mNtex^{-1}$)	9.92 ± 2.72	41.84 ± 4.92	33.12 ±9.96	24.29 ± 7.18	11.98 ±3.95	13.91 ± 4.15	34.11 ± 13.12
Breaking extension (%) (corrected for crimp)	4.02 ± 2.28	5.74 ± 0.33	5.36 ± 0.66	3.90 ± 1.02	3.05 ± 1.30	2.65 ± 1.18	5.78 ± 1.20
Crimp (%)	3.90 ± 2.13	2.00 ± 0.59	3.18 ± 0.53	2.57 ± 1.24	2.15 ± 1.01	1.96 ±1.43	3.96 ± 1.62

Properties were determined at ambient temperature (30°C).

Table II Composition and Density of Fibers

Parameter	*Avaria chamae*	*Corchorus olitorius*	*Corchorus tridens*	*Fiscus thonningii*	*Grewia mollis*	*Hibiscus miranthus*	*Hibiscus rostellatus*
Density ($g\ cm^{-3}$)	1.125	0.791	1.105	0.863	1.720	1.047	1.365
Moisture (%)	2.00	2.88	5.00	1.98	7.00	6.00	5.88
ASh (%)	3.20	4.80	—	—	6.4	5.6	—

ble to the values for *Adansonia digitata* and *Hibiscus esculentus,*[8] i.e., 50 and 90 $mNtex^{-1}$, respectively.

The breaking extension for the fibers at ambient temperature after correcting for crimp is in the range of 2.65–5.74%, the range normally found for cellulosic bast fibers.[1] In principle, these results reflect varying morphological characteristics of the fibers, notably the degree of order, the angular orientation of the molecules along the fiber axis, and fiber-fiber bonding.[5,12,13] Moreover, the tensile properties of the fibers in the native forms are generally low, to compete with the conventional ones, and may consequently require further treatment for their improvement.

The densities of cellulosic fibers are normally in the range of 1.45–1.65,[4,5] but as can be seen in Table II, only the value for *H. rostellatus* (1.365 $g\ cm^{-3}$) falls within the range, whereas for *G. mollis* it is above the range at 1.720 $g\ cm^{-3}$. For *C. olitorius* and *F. thonningii,* the densities are less than unity, suggesting, as indicated previously,[8] the possibility of internal void spaces[1] in the fibers and of microstructures of low molecular order. The ash and moisture content of the fibers are not higher than 3.20 and 6.00%, respectively, as shown in Table II.

CONCLUSION

This study has shown that the tensile properties of the fibers in the native form are generally low compared with those of the conventional cellulosic bast fibers, with initial moduli and tenacities that are not higher than 0.82 ± 0.10 and 41.84 ± 4.92 $mNtex^{-1}$, respectively, under ambient temperature conditions. The specific work of rupture in the range 1.34 ± 0.32–1.65 ± 0.89 $mNtex^{-1}$ for *C. tridens, C. corchorus,* and *H. rostellatus* are up to a factor of four lower than the values for some conventional cellulosic bast fibers.

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