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Chemistry of lignin in *Sonneratia apetala* (Keora) wood of Bangladesh

Background

Sonneratia apetala (Keora) is one of the main mangrove species of Bangladesh. The species is a small tree up to 20 m tall with drooping branches and twigs (Giesen *et al.*, 2007). Flowers are an important source of honey, young leaves are favoured by deer, and wood is used for planks, boxes and firewood. From 1960 to 2000, the Forest Department has established 140,000 ha of mangrove plantations of primarily keora in the coastal region of Bangladesh under various coastal afforestation projects (Hoque & Datta, 2005). Being a fast-growing species, planted trees are now fully matured with individuals reaching 30 cm in diameter (Fig. 1). At present, this species has neither industrial nor other applications. The Kharnaphuli Paper Mill in Chittagong is the only mill manufacturing printing and writing paper from bamboo (Gupta, 1999). The Khulna Newsprint Mill, which used to produce newsprint from Gewa (*Excoecaria agallocha*), was shut down due to inadequate supply of raw materials. There is a need to seek alternative resources for the mill at Khulna. Some pulping properties of Keora have been studied (Jahan *et al.*, 2009). This paper reports on the chemistry of lignin in Keora and results showed that the species may be a new resource of pulp for medium quality paper.

Fig. 1. A mature Keora tree with dark fissured bark

Materials and methods

Keora wood was collected from a 10-year old tree in the Sundarban area. The wood was chipped and ground in a Wiley mill (40/60 mesh) for chemical analysis. Fiber length and width were determined using methods reported by Jahan *et al.* (2009).

Lignin was extracted with alcohol-benzne solvent and extract free wood meal was refluxed by acidic dioxane (9:1) solution (Jahan & Mun, 2007). After alkaline nitrobenzene oxidation (ANO), ^{1}H-NMR spectroscopy of lignin solution (100 mg of acetylated lignin contained in 0.5 ml of deuterated chloroform) was conducted with a Bruker 400 spectrometer.

Results and discussion

Density of Keora was 0.59 g/cc (Table 1), which is quite good for industrial raw materials. Fiber length of 0.88 mm was in the range of tropical hardwoods (0.7–1.5 mm) and considered as short fiber. Klason lignin content was 27.4%, which was higher than temperate hardwoods and within the range of tropical hardwoods including *Acacia auriculiformis* (Jahan *et al*., 2008). Acid soluble lignin content of 4.15% was higher than the normal range of hardwood. Alpha-cellulose content of 38.1% was lower than other hardwoods grown in Bangladesh (Jahan & Mun, 2003). The lower alpha-cellulose content in Keora would imply lower pulp yield. Pentosan content was 21.6%, which was higher than that of *A. auriculiformis*.

Table 1. Properties of Keora wood

Alpha-cellulose content	38.1%
Lignin content	
Klason	27.4%
Acid soluble	4.15%
Pentosan content	21.6%
Fiber length	0.88 mm
Fiber width	21.3 μm
Density	0.59 g/cc

Predominant constituents of Keora lignin was syringaldehyde (20.8%) followed by vanillin (13.1%) and syringic acid (2.10%) (Table 2). Syringaldehyde was formed by degradation of non-condensed syringyl and guaiacyl units. Their total yield of 36% reflects an abundance of condensed structure in Keora lignin. Molar ratio of syringyl to guaiacyl lignin was 1.76, suggesting easier delignification.

Table 2. Constituents of Keora lignin

Vanillin (V)	13.1%
Syringaldehyde (S_1)	20.8%
Syringic acid (S_2)	2.10%
Total	36.0%
(S_1+S_2)/V molar ratio	1.76

^{1}H-NMR spectrum of Keora lignin showed two peaks in the aromatic proton region, which correspond to guaiacyl units (δ 6.9) and syringyl units (δ 6.6) (Fig. 2). The proportion of syringaldehyde units was higher than that of guaiacyl units. Keora lignin also showed that the structural element may contain both *erythro* and *threo* configurations due to the presence of protons at the C-α position of the side chain. The *erythro* protons give a stronger peak at 6.01 ppm than the corresponding peak for the *threo* form at δ 6.09.

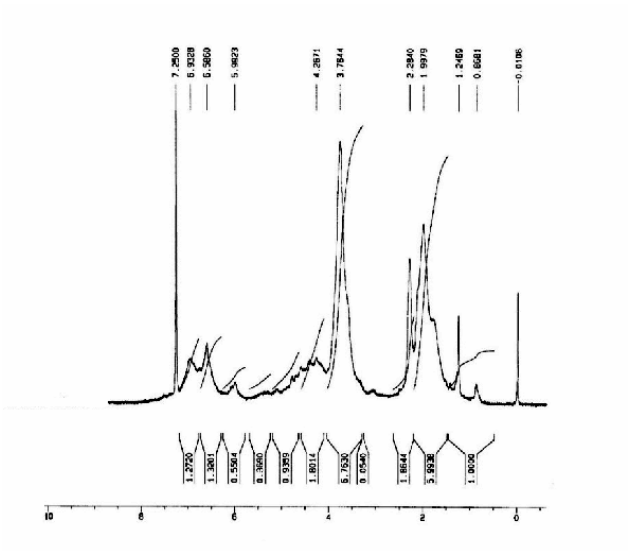

Fig. 2. ^{1}H-NMR spectrum of Keora lignin

Conclusions

Keora wood fiber is short length. Cellulose content is lower and lignin content slightly higher than other hardwoods. Its lignin structure is composed mainly of syringyl units like other hardwood lignins. It is concluded that the wood of Keora can be used as newsprint grade pulping material.

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