Development of kenaf binderless composite panels

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In recent years, effective utilization of fast-growing non-wood lignocellulosic materials and agro-wastes has been of great interest owing to a drastic fall in forest resources. Among the nonwood lignocellulosic materials, kenaf (*Hibiscus cannabinus L.*) has attracted special interest because of its rapid growing speed. Kenaf is an annual plant. The stalk contains two different types of fiber, an outer "bast" and an inner "core". The bast fiber provides high strength and can be converted into a high-performance oriented MDF [1], it is also a potential overlay material for making kenaf composite panel, while the kenaf core is extremely light in weight with the density around 0.15g/cm^3, which is a good material for low-density board [2].

Synthetic binders are usually used for wood-based panel production. They are not only expensive, but also derived from non-renewable petro resources. Efforts have been done to develop binderless boards by using steam-explosion or high-temperature hot-pressing processed [3][4]. But the binderless board with high densities can usually be produced. Kenaf core is not only very light in weight, but also rich in hemicelluloses which may act as a binder when making board. It seems to be a good possibility for producing binderless boards using kenaf core.

The main objective of this study is to develop binderless (no binder) boards with relatively low density by using kenaf as raw material, including 3 main portions: Development of binderless particleboard from kenaf core using steam-injection pressing method; reinforce binderless particleboard with bast fiber-woven sheets; and development of binderless fiberboard from kenaf core using conventional dry-process fiberboard manufacturing.

Binderless particleboards were developed from kenaf core using steam-injection pressing [5][6]. The effects of board density, steam pressure and treatment time on the properties of the board were evaluated. The target board densities were relatively low, ranged from 0.10-0.70 g/cm^3. The properties of the boards increased linearly with increasing board density (Fig.1). Steam pressure and treatment time also affected the board properties. The bending strength and internal bond (IB) strength were improved with increasing steam pressure. A long steam treatment time contributed to low thickness swelling (TS) values and thus better dimensional stability. The appropriate steam pressure was 1.0 MPa, and the treatment time was 10-15 min. The properties for 0.55 g/cm^3 density boards under optimum conditions were: modulus of rupture (MOR) 12.6 MPa, modulus of elasticity (MOE) 2.5 GPa, IB 0.49 MPa, TS 7.5% and wet MOR 2.4 MPa. Compared with the requirement of JIS 5908, 1994 for particleboard, kenaf binderless boards showed excellent IB strength but relatively low durability. The thermal conductivity of the low-density kenaf binderless particleboards showed values similar to those of insulation material (i.e., rock wool). The boards with densities of 0.15-0.20 g/cm^3 are promising building materials for thermal insulation applications.

In order to improve the bending strength of low-density kenaf binderless particleboard, kenaf composite panel, that is, binderless particleboard reinforced with kenaf bast-fiber woven sheets was manufactured [7]. Compared with single-layer binderless particleboard, the bending strengths in dry and wet conditions, and the dimensional stability in the plane direction of composite panels were improved. The kenaf composite panel with a density of 0.45 g/cm^3 gave the properties of: dry MOR 14.5 MPa, dry MOE 2.1 GPa, wet MOR 2.8 MPa, IB 0.27 MPa, TS 13.9%, and linear expansion (LE) 0.23%. During binderless particleboard manufacturing, steam treatment (0.6-1.0 MPa) could cause significant change of chemical components of kenaf core, and self-bonding was achieved among particles [8].

Binderless fiberboards from kenaf core were manufactured using conventional dry-process fiberboard manufacturing without any other special treatment. Kenaf chips were converted into fibers and then hot pressed into fiberboards. The effect of steam pressure (0.4-0.8 MPa) and cooking time (10-30 min) in the refining process, fiber moisture content (MC) (10%, 30%), hot pressing time (3-10 min) on the board properties were investigated. Chemical analysis of fibers and binderless fiberboards was also done to investigate the changes of chemical components during board manufacturing process. The results showed that kenaf core binderless fiberboards manufactured with high steam pressure and long cooking time during the refining process had high IB strength, low TS, but low bending strength values. The binderless fiberboards made from 30% MC fibers showed better mechanical and dimensional properties than those from air-dried fibers. At a density of 0.5 g/cm^3, binderless fiberboard with the refining condition of

0.8MPa/20min recorded: MOR 12MPa, MOE 1.7GPa, IB 0.43MPa, TS 12.1% under the optimum board manufacturing conditions. These values are similar to that of binderless particleboard at the same density level. However, the manufacturing process of binderless fiberboard is simpler and can easily be applied to commercial production at present time.

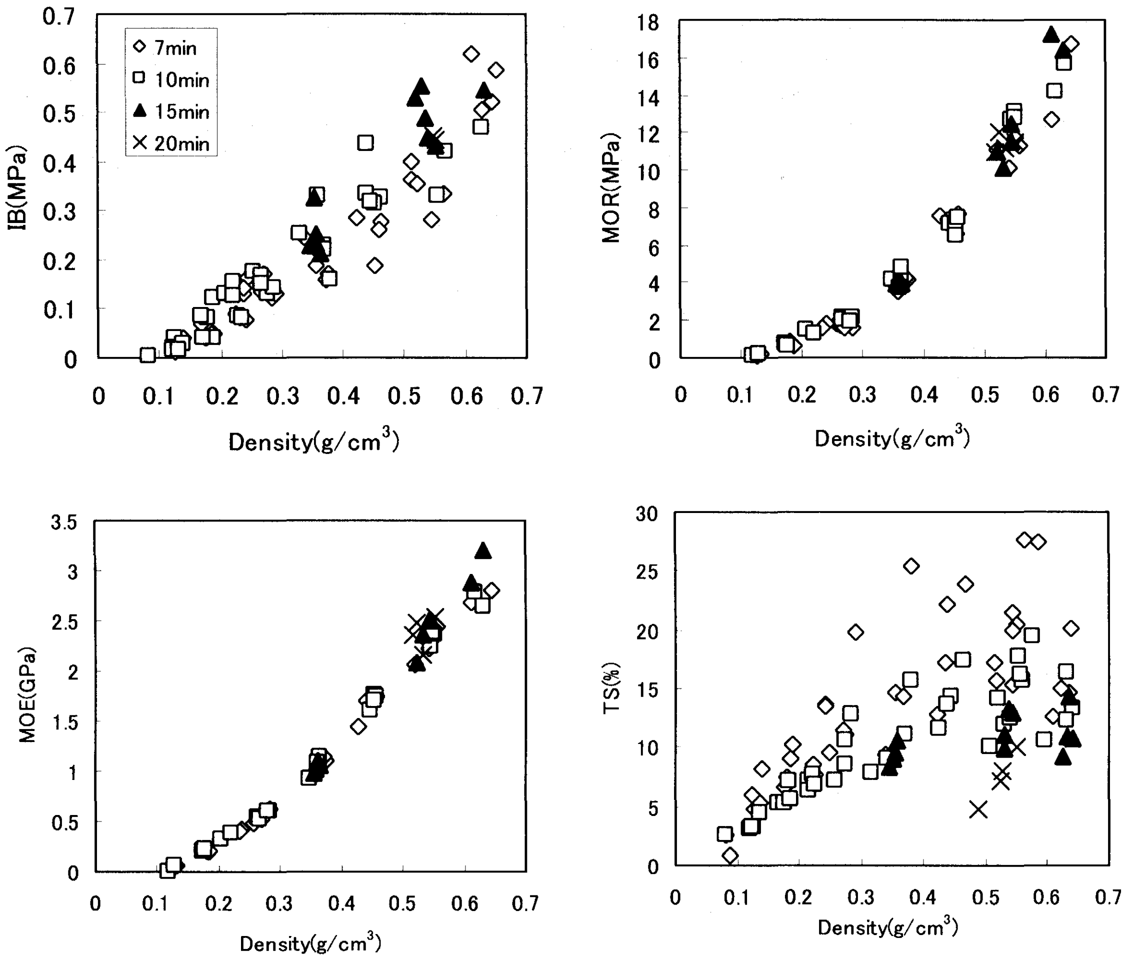

Fig.1. Effect of board density and steam treatment time on the properties of kenaf binderless particleboard. Steam pressure was 1.0MPa

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