ABSTRACTS (PH D THESIS)

Development of particleboard made from sweet sorghum bagasse and citric acid

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Sweet sorghum bagasse as a non-wood lignocellulose material that contain high hemicellulose (33.95%) [1] is a promising substitute wood material for the manufacture of particleboard. The high content of hemicellulose probably would make sweet sorghum bagasse react effectively with citric acid as a natural adhesive, hence the particleboard made from sweet sorghum bagasse bonded with citric acid would have good bondability. Therefore, the objective of this study is to utilize sweet sorghum bagasse in the manufacturing of environmentally friendly particleboard bonded with citric acid. The optimization of the manufacturing conditions of particleboard such as pre-treatment of particles before hot pressing condition, citric acid contents, pressing temperature and time that influence the physical properties of particleboard were investigated. The improvement of the particleboard physical properties was observed by addition of sucrose.

Optimization of manufacturing conditions

Pre-treatment optimization of particles before pressing were decided by investigation of pre-drying and non drying treatment of sprayed particles to observe the effect of the pre-pressing moisture content of sprayed particles on the physical properties of the particleboards [1]. In addition, the effect of the citric acid (CA) content on the physical properties of the particleboards was investigated. The boards were manufactured under the pressing conditions of 200 °C for 10 min. The citric acid content was varied in the range of 0 to 30 wt% [1]. The board size and target density were 300 x 300 x 9 mm and 0.8 g/cm3, respectively. Particleboards manufactured using phenol formaldehyde (PF) resin and polymeric 4,4'-methylenediphenyl isocyanate (pMDI) were used as references. The physical properties of boards prepared using pre-dried particles were superior to those of the boards prepared using non-dried particles [1]. The physical properties of boards were improved with increasing citric acid content up to 20 wt% [1]. The physical properties of boards bonded with 20 wt% citric acid satisfied the requirement of the JIS A 5908 (2003) 18 type [1]. In addition, the physical properties of the board were comparable to those of boards bonded using PF resin and pMDI. Infrared (IR) spectral analysis suggested the presence of ester linkages, indicating that the carboxyl groups of citric acid had reacted with the hydroxyl groups of the sweet sorghum bagasse to give the boards good physical properties [1]. Consequently, it was concluded that pre-drying treatment of the particles and a citric acid content of 20 wt% were effective in manufacturing particleboards composed of sweet sorghum bagasse and citric acid. In addition, the pressing temperature and time condition which used in this step was only one condition at high pressing temperature of 200 °C and long pressing time relatively for 10 min. Therefore, the second step was carried out the particleboard manufacturing with the several pressing temperatures (i.e. 140, 160, 180, 200, 220 °C) and times (i.e. 2, 5, 7, 10, 15 minutes) [2].

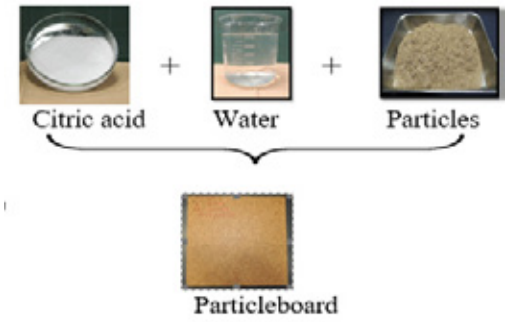

Figure 1. The production of particleboard from sweet sorghum bagasse and citric acid.

The effects of pressing temperature and time on physical properties such as dry-bending (DB), internal bond strength (IB), and thickness swelling (TS) of particleboard were investigated. Wet bending (WB), screw-holding power (SH), biological durability, and formaldehyde emission of particleboard manufactured under effective pressing temperature and time were also evaluated. The results showed that the effective pressing temperature and time were 200 °C and 10 min, respectively [2]. It was clarified that

DB, IB, and TS satisfied the type 18 requirements of the JIS A 5908 (2003), and its dimensional stability was comparable to those of particleboard bonded with PF and pMDI [2]. However, the SH of particleboard did not satisfy type 18 of JIS [2]. Particleboard manufactured under effective pressing conditions had good biological durability and low formaldehyde emission [2]. Based on the results of infrared spectra (IR) measurement, the degree of ester linkages increased with increased pressing temperature and time. On the other hand, high content of citric acid i.e. 20 wt% seem to be probably the particleboard become brittle, hence MOR and screw holding power were lower than those of particleboard bonded with PF and or pMDI. Therefore, the improvement of those properties were observed by adding sucrose to the adhesion system in manufacturing of particleboard, hence the content of citric acid will be reduced.

Improvement of the particleboard physical properties by addition of sucrose

The effects of the ratio (i.e. 100:0, 75:25, 50:50, 25:75, 20:80, 15:85, 10:90, 0:100) between citric acid (CA) and sucrose (SU) on the physical properties of the particleboards were investigated [3]. Based on the effective conditions of particleboard manufacturing as discussed in the optimization of manufacturing conditions, the particleboards were manufactured using pre-drying treatment particles before hot pressing and pressed under 200 °C for 10 min. Those particleboards were bonded with 20 wt% of CA-Su-based adhesive under several weight ratios of CA to SU. The mechanical properties of particleboards bonded with CA-SU based adhesive under 15/85 and 10/90 ratio of CA to Su were superior to those of the particleboard under other conditions of the ratio [3]. In addition, the physical properties of the particleboard bonded with CA-SU based adhesive under 15/85 and 10/90 ratio of CA to SU were comparable to those of particleboard bonded using phenol formaldehyde (PF) resin and satisfied the requirement of the 18 type JIS A 5908 (2003) [3]. The brittleness of the particleboards were decreased effectively by adding sucrose. The low formaldehyde emission and good biological durability against termite and decay were obtained by particleboard under effective ratio of CA to Su [3]. According to the results of thermal analysis and infrared spectra measurement, the ester linkages was generated by the reaction between CA, Su and SSB components [3].

Conclusions

Development of particleboard using sweet sorghum bagasse, citric acid, and sucrose had some benefit values of environmental and technical aspects. Utilization of sweet sorghum bagasse in the manufacturing of particleboard could reserve the carbon for long term. In addition, citric acid, sucrose as sustainable natural resources have well prospective to substitute petroleum resources for particleboard adhesive. Technically, the particleboard had good physical properties, free from formaldehyde emission and good durability against termite and decay.

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