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Structure Characteristics of Oxidation Pretreated Fiber and Biochemically Binded Boards against Gravida Abortion

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More and more gravida abortion has been induced by indoor formaldehyde, and are severely threat public health. To fundamentally eliminate indoor formaldehyde pollution, wood fiber was pretreated by oxidation, biochemically binded during hot press, and analyzed by FT-IR and SEM. The results shown that the bond strength of biochemically binded boards was higher during the SYG pretreat than during the SQG pretreat. SEM analysis showed that the broke biochemically binded boards by SYG pretreat relative to SQG pretreat, the length of bulgy fiber was more consistent, the interface was more inseparable, cavitationis was lower, fracture behavior was ductile rupture. FT-IR spectrum showed that the absorbance of many connection binds such as –OH increased during the SYG pretreat, and it could be inferred that more binds were produced and played the role of molecular crosslinking. Anyhow, it suggested that the SYG pretreated was better than the SQG pretreated for the biochemically binded boards whose bond strength reached the maximum value 0.72 MPa (SQG) and 0.27 MPa (SYG) for 10h.

Key words: FT-IR, SEM, Biochemically binded boards, Formaldehyde pollution, Gravida abortion.

Gravida indicated that the woman had been pregnant for the number of times[1]. Although the woman was in a state of pain, her fimily was full of love and joy[2,3]. However, gravida had abortion which was the number of spontaneous or therapeutic abortions, and birth was the number born deceased. Even worse, the fimily was full of pain and sad[1-5]. There were many reasons which could cause abortion[3-6]. For example, Gravida took the wrong medicine or food. And gravida falled or intense impacted. During pregnancy, women reduced immunity[5-7]. If formaldehyde air was absorbed into the body and went into the blood, immune cells would be killed. It would initiated that women reduced less and less immunity and aborte[2-7]. Further researches showed that more and more gravidas aborted where they lived in indoor formaldehyde pollution which came from wood-based panels productions, Gravida abortion had be more than 2,000,000 cases per year in China. Besides, unintended pregnancy was the major contributor to abortion. And the elimination of indoor formaldehyde pollution was a key public health security.

Since the birth of wood-based panels, the people's demand of biochemically binded boards had been grown more and more eagerly with no formaldehyde emission[8-11]. Biochemically binded boards were one kind of wood-based panels with wood fiber binded together without resin under pressure and heat. And the biochemically binded boards was improved by activating the components of wood fibers during hot press[12]. With the eager market demand of biochemically binded boards, it was the scientific research task to find out the

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biochemically binding mode of fiber, especially the groups of the fibers during hot press. Therefore, to improve the biochemically binding reactivity, *Eucalyptus urophydis* wood fibers were pretreated by acidic oxidation and alkaline oxidation, processed by hot press, and analyzed by FT-IR and SEM.

MATERIALS AND METHODS

Eucalyptus urophydis wood, which was 4.5-years-old, collected from Yangjiang forest zone in Guangdong Province China. And the wood was processed into wood chips, dried to oven dry, and mechanically disintegrated to 40-60 mu short fiber[13]. NaOH, Na_2SiO_4, CH_3COOH and H_2O_2 (30%), which were prepared for the subsequent experiments, were analytical reagent.

Oxidation pretreat

The above short fiber was weighed, and each was 100 g (accuracy1.0mg), and was pretreated in oxidation solution for 5h, 10h, 15h and 20h at room tepperature, respectively. The oxidation solutions were SQG (the mass percentage concentration of H_2O_2, NaOH and Na_2SiO_4 was 1%, 0.5%, and 0.2%, respectively) and SYG (the mass percentage concentration of H_2O_2, CH3COOH and Na_2SiO_4 was 1%, 0.5%, and 0.2%, respectively). After pretreatment, the short fiber was filtered, dried at room temperature, done to oven dry at 103ºC. The pretreated fiber was named SQG11, SQG12, SQG13, SQG14; SYG11, SYG12, SYG13, SYG14, respectively.

Biochemically binding process

The 90g above fiber was biochemically binded at 160ºC under the pressure of 15MPa for 20min, respectively. The biochemically binded boards were obtained and named SQG21, SQG22, SQG23, SQG24; SYG21, SYG22, SYG23, SYG24, respectively. Their bond strength was detected according to the Chinese national standards GB/T11718-2009.

FT-IR detection

Fourier transform infrared spectrum (FT-IR) spectra of the above samples were obtained using a Thermo Scientific Nicolet iN10 FT-IR microscope as previously[11, 12].

SEM observations

The sample surfaces were coated in a vacuum evaporator with a thin film of Au (JFC-1600) and observed using an SM6490LV microscope[11].

Results and Analysis

Bond strength of biochemically binded boards

The bond strength was the main mechanical strength of biochemically binded boards. The detected results showed that the bond strength of SQG samples were 0.04 MPa, 0.27 MPa, 0.08 MPa, 0.04 MPa when the fiber was pretreated for 5h, 10h, 15h and 20h, respectively; the bond strength of SYG samples were 0.07 MPa, 0.72 MPa, 0.07 MPa, 0.06 MPa when the fiber was pretreated for 5h, 10h, 15h and 20h, respectively. The effect of oxidation pretreatment time on bond strength was significant. With the increase of pretreatment time, the bond strength firstly increased and then decreased, reached the maximum value 0.72 MPa (SQG) and 0.27 MPa (SYG) for 10h. The reason was that the components of *Eucalyptus* wood fiber were degraded and produced active groups when oxidation pretreat was initial. However, the components of *Eucalyptus* wood fiber were overly degraded so as to decrease the bond strength of biochemically binded boards. The further results yet need further analysis.

Group characteristics of wood fiber during oxidation pretreat

FT-IR spectra could be used to investigate the structural goups of the wood fiber samples during auto oxidation pretreat. For comparison, the spectra of the pretreated wood fiber were plotted in supporting information Fig.1 and Fig.2.

FT-IR spectra could be used to investigate the structural goups of the pretreated wood fiber. The spectra of all samples showed the O-H stretch at 3345cm^{-1}, -CH_2 stretch at 2916cm^{-1}, unconjugated C=O stretch at 1735cm^{-1}, C-H deformation vibration at 1459cm^{-1}, C-H bending vibration at 1372cm^{-1}, C-C, C-O plus C=O stretch at 1235cm^{-1}, C-O-C stretch at 1160cm^{-1}, C-O or C-C stretch at 1113cm^{-1}, C-O-C stretch at 1032cm^{-1}, cellulose beta glycosidic bind stretching vibration at 898cm^{-1}. Fig.1 showed that the spectra of pretreated wood fiber were plotted in supporting information. During the SQG pretreat, the absorbance of O-H stretch peak became lower, it mented that tne number of O-H decreased. the absorbance of unconjugated C=O stretch peak increased because C-OH, C-C and C=C were oxidized and produced C=O. In the alkaline solution, some lignin was leached out, and Ar-CR

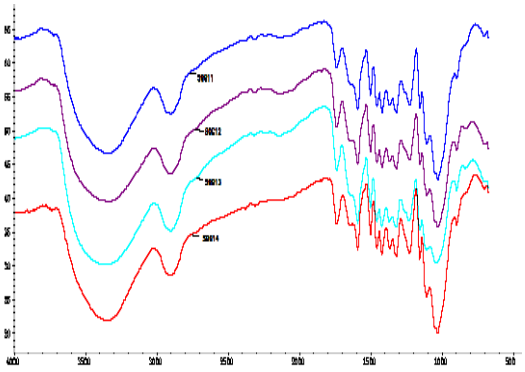

Fig.1. FT-IR spectra of *Euralytus* wood fiber during SQG pretreatment

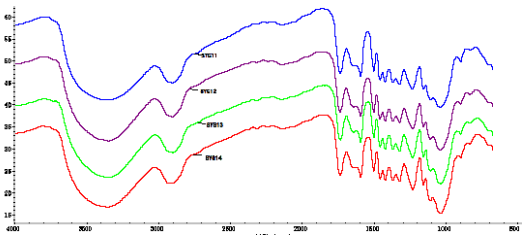

Fig. 2. FT-IR spectra of *Euralytus* wood fiber during SYG pretreatment

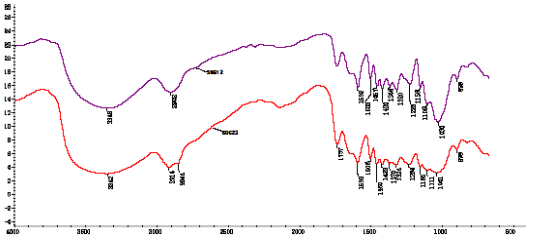

Fig. 3. FT-IR spectra of biochemically binded boards by SQG pretreatment

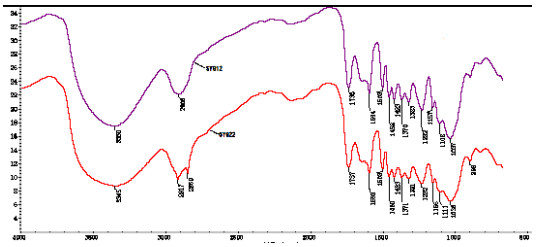

Fig. 4. FT-IR spectra of biochemically binded boards by SYG pretreatment

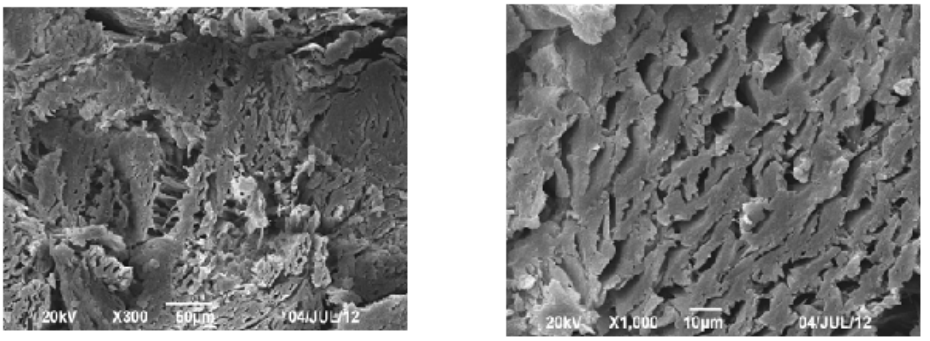

Fig. 5. SEM of biochemically binded boards SQG23 after wood fiber was pretreated in SQG

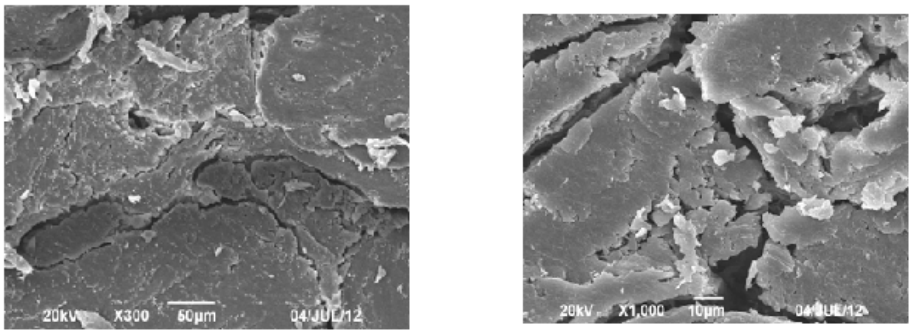

Fig. 6. SEM of biochemically binded boards SQG24 after wood fiber was pretreated in SQG

was also oxidized, it could result that aromatic skeletal vibrations in the lignin samples (1591cm^{-1}, 1504cm^{-1}, and 1423cm^{-1}) decreased. Moreover, the absorbance of C-H (1460cm^{-1}) and C-O-C (1030cm^{-1}) peaks both decreased.

Fig.2 showed that the spectra of pretreated wood fiber were plotted in supporting information. During the SYG pretreat, the absorbance of O-H stretch peak became higher, it mented that tne number of O-H increased. The absorbance of unconjugated C=O stretch peak increased because C-OH, C-C and C=C were oxidized and produced C=O. In the alkaline solution, some Ar-CR was also oxidized, it could result that aromatic skeletal vibrations in the lignin samples (1591cm^{-1}, 1504cm^{-1}, and 1423cm^{-1}) decreased. Moreover, the absorbance of C-H (1458cm^{-1}) and C-O-C (1027cm^{-1}) peaks both decreased.

Group characteristics of biochemically binded boards

FT-IR spectra could be used to investigate the structural goups of biochemically binded boards. For comparison, the FT-IR spectra of biochemically binded boards were plotted in supporting information Fig.3 and Fig.4.

As could be seen from the Fig.3, after the biochemically binded boards made by the SQG pretreated wood fiber, the absorbance of O-H stretch peak became lower, it mented that some O-H might produce hydrogen bond. The absorbance of unconjugated C=O stretch peak decreased, resulting that some C=O and -COOH might produced link polymerization. The skeletal vibrations of lignin (1591cm^{-1}, 1504cm^{-1}, and 1423cm^{-1}) decreased, resulting that some lignin might produced the chemical bonding reaction. The 1156cm^{-1} and 1368cm^{-1} peaks became lower, suggesting that cellulose reacted. Moreover, the

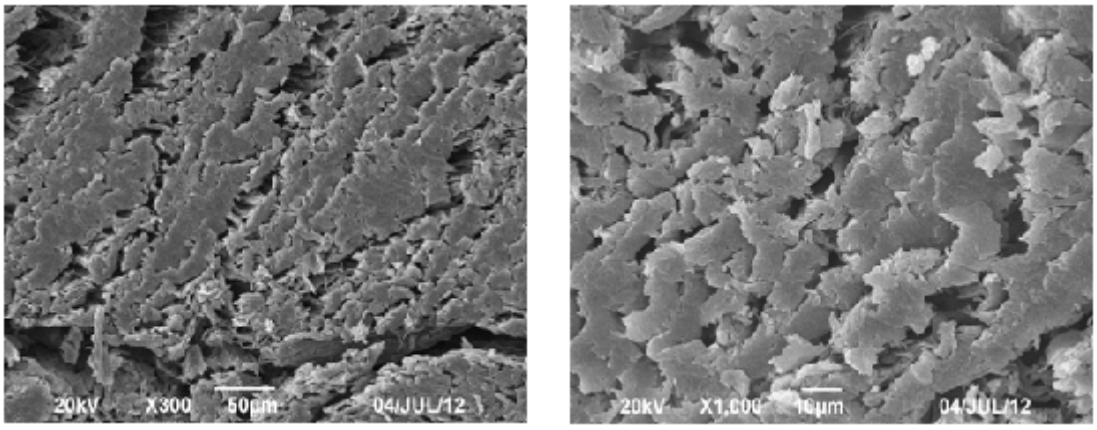

Fig. 7. SEM of biochemically binded boards SYG22 after wood fiber was pretreated in SYG

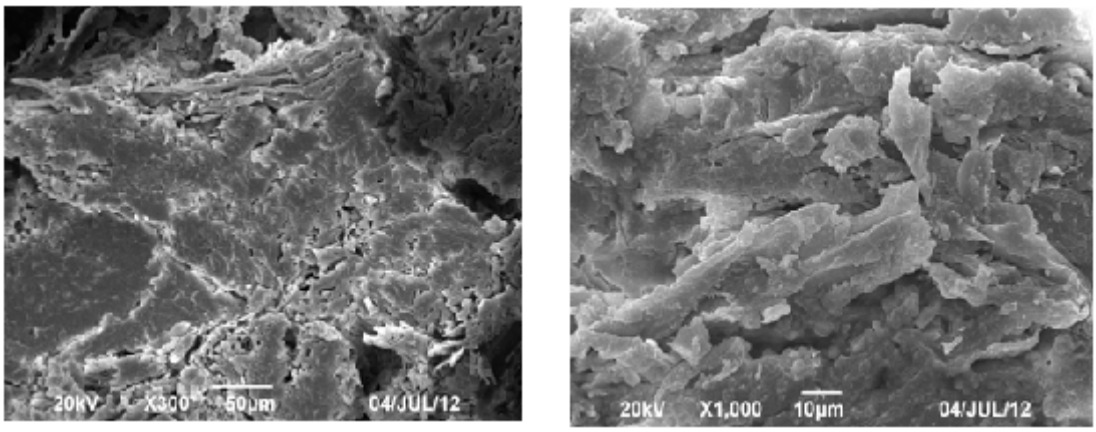

Fig. 8. SEM of biochemically binded boards SQG21 after wood fiber was pretreated in SYG

absorbance of C-C or C-OC-H (1106cm^{-1}), C-H (2902cm^{-1}) and C-O-C (1030cm^{-1}) peaks both decreased.

As could be seen from the Fig.3, after the biochemically binded boards made by the SYG pretreated wood fiber, the absorbance of O-H stretch peak became lower, it mented that some O-H might produce hydrogen bond. The absorbance of unconjugated C=O stretch peak decreased, resulting that some C=O and -COOH might produced link polymerization. The skeletal vibrations of lignin (1591cm^{-1}, 1504cm^{-1}, and 1423cm^{-1}) decreased, resulting that some lignin might produced the chemical bonding reaction. The 1156cm^{-1} and 1368cm^{-1} peaks became lower, suggesting that cellulose reacted. Moreover, the absorbance of C-C or C-O (1107cm^{-1}) , C-H (2906cm^{-1}) and C-O-C (1032cm^{-1}) peaks both decreased.

According to the above analysis results, after the pretreated wood fiber was biochemically binded, groups had the approximate variation characteristics (seen in Fig.3 and Fig.4). Hower, the bond strength of biochemically binded boards pretreated by SQG was higher than by SYG. It suggested that the SYG pretreated was better than the SQG pretreated for the biochemically binded boards.

Morphology characteristics of biochemically binded boards

Scanning electron microscope (SEM) could observe the small changes of biochemically binded boards. Fig.5, Fig.6, Fig.7, and Fig.8 showed SEM photo of SQG23 sample with the maximum bond strength, SQG24 sample with the mimimum bond strength, SYG22 sample with the maximum bond strength, SYG21 sample with the mimimum bond strength. As could be seen from the Fig. 5 and Fig.7, when the biochemically binded boards SYG22 of wood fiber by SYG pretreat broke, the length of bulgy fiber was more consistent, the interface was inseparable, cavitationis was low, fracture behavior was ductile rupture according to the fracture surface morphology; however, when the biochemically binded boards SQG23 of wood fiber by SQG pretreat broke, the length of bulgy fiber was inconsistent, cavitationis was many, fracture behavior was pull-off phenomenon according to the fracture surface morphology. So the biochemically binded boards SYG22 of wood fiber by SYG pretreat were better than those by SQG pretreat. As could be seen from the Fig.7 and Fig.8, the interface was clearland loose with the large of cavitationis, and ite bond strength reached the mimimum; the interface was vague and inseparable with the teared fiber, and ite bond strength reach the maximum.

CONCLUSION

With the extension of pretreatment time, the bond strength firstly increased and then decreased, reached the maximum value 0.72 MPa (SQG) and 0.27 MPa (SYG) for 10h. And the bond strength of biochemically binded boards was higher during the SYG pretreat than during the SQG pretreat.

FT-IR spectrum showed that the groups of wood fiber both changed during the SYG pretreat and the SQG pretreat. And the absorbance of many connection binds such as –OH increased during the SYG pretreat. It could be inferred that many binds were produced and played the role of molecular crosslinking. Hower, the bond strength of biochemically binded boards pretreated by SQG was higher than by SYG. It suggested that the SYG pretreated was better than the SQG pretreated for the biochemically binded boards.

SEM results showed that the biochemically binded boards broke when wood fiber was done by SYG pretreat, the length of bulgy fiber was consistent, the interface was inseparable, cavitationis was low, fracture behavior was ductile rupture. However, when the biochemically binded boards broke when wood fiber was done by SYG pretreat, the length of bulgy fiber was inconsistent, cavitationis was many, fracture behavior was pull-off phenomenon according to the fracture surface morphology. It was resulted that the biochemically binded boards SYG22 of wood fiber by SYG pretreat were better than those by SQG pretreat.

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REFERENCES

1. Karen, P., Andreea, A. C., Kim, D. B., Denise J. J.. Abortion Surveillance — United States, 2011. *Surveill. Summar.*, 2014; **63**: 1-41
2. Jones, R.K., Jerman, J.. Abortion incidence and service availability in the United States, 2011. *Persp. Sex Reprod. Health*, 2014; 46:3–14.
3. Jones, R.K., Kavanaugh, M.L.. Changes in abortion rates between 2000 and 2008 and lifetime incidence of abortion. *Obstet Gynecol*, 2011; 117: 1358–66.
4. Jones, R.K., Kooistra, K.. Abortion incidence and access to services in the United States, 2008. *Persp. Sex Reprod. Health*, 2011; **43**: 41–50.
5. Jones, R.K., Kost, K., Singh, S., Henshaw, S.K., Finer, L.B.. Trends in abortion in the United States. *Clin Obstet Gynecol*, 2009; **52**: 119–29.
6. Peipert, J.F., Madden, T., Allsworth, J.E., Secura, G.M.. Preventing unintended pregnancies by providing no-cost contraception. *Obstet Gynecol*, 2012; **120**: 1291-7.
7. Juan, R.V., Esteban, R., David, C., Juanita, F., Jaime, R.. Fiberboard Manufactured Without Resin Using The Fenton Reaction. *J. Chil. Chem. Soc*, 2008; **53**(4): 1722-1725
8. Sun, Y.C., Lin, Z., Peng, W.X., Yuan, T.Q., Xu, F., Wu, Y.Q., Yang, J., Wang, Y.S., Sun, R.C.. Chemical changes of raw materials and manufactured binderless boards during hot pressing: Lignin isolation and characterization. *BioResources*, 2014; **9**(1): 1055-1071
9. Xiao, L.P., Lin, Z., Peng, W.X., Yuan, T.Q., Xu, F., Li, N.C., Tao, Q.S., Xiang, H., Sun, R.C.. Unraveling the structural characteristics of lignin in hydrothermal pretreated fibers and manufactured binderless boards from Eucalyptus grandis. *Sustain. Chem. Proces.*, 2014; **2**: 9
10. Xue, Q., Peng W.X., Makoto O.. Molecular Bonding Characteristics Of Self-Plasticized Bamboo Composites. *Pak. J Pharm. Sci.*, 2014; **27**: 975-982
11. Wen, J. L, Sun, S. L., Xue, B. L., Sun, R. C. Quantitative structures and thermal properties of the birch lignins after ionic liquid-based biorefinery. *J. Agric. Food Chem.*, 2013; **61**: 635-45.
12. Peng, W.X.ÿLin, Z.ÿLi, N.C.. Effects of alkali treatment on mechanism of extrusion bonding of eucalyptus wood fiber. *Eng. Sci.*, 2014; **16**(4): 66-70