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CHARACTERISTICS OF NONTOXIC BAMBOO BIOBOARD BY MELAMINE AND CELLULOSE ADHESIVE

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ABSTRACT

In this research, the influence of various factors on the performance of the melamine bamboo cellulose gum is investigated by orthogonal test method, with the pressing temperature, pressing time, the added amount of cellulose gum, melamine dosage as factors. And analyze the samples by Fourier transform infrared spectroscopy (FTIR), thermo gravimetric analysis (TGA), DTG, etc. The amount of melamine is the main factor affecting the quality of bamboo composite material and its physical and mechanical properties, it has a significant impact on MOR board, internal bond strength, elastic modulus and other properties; cellulose gum is a secondary factor affecting performance. The results showed that cellulose gum ratio of 5 %, ratio of melamine of 2.5 % and the hot press time of 9 min provided the optimum conditions for hot press.

KEYWORDS: Industrial bamboo, melamine and cellulose adhesive, FTIR, TGA/DTG.

INTRODUCTION

With the worldwide shortage of forest bioresources, the global supply of raw biomaterial is increasingly tense. The problems of lack of panel production and raw materials prices restricted the development of plywood industry. These make it necessary to develop new types of wood-based panels (Cong et al. 2014, Yanlan et al. 2014). China is rich in bamboo resources, known as "bamboo Kingdom" (Fangrong et al. 2010). Resin adhesive is dry fiberboard production and use of the product, resulting in large amounts of formaldehyde, free phenol or other harmful pollutants, a serious threat to people's life and health and safety ring habitat (Zhongrong et al. 2001, Chunde et al. 2007). In order to eliminate the negative impact of a resin such as urea-formaldehyde glue, some researchers has used a variety of methods of physical, chemical, biological and other non-wood fibers to explore ways to achieve glued. Since 1939 Tischer created a surface chemical wood treatment method, which began the study of the field of binderless glue, Zhang Guilin increased the content of free radicals in wood fiber cells by physical and chemical methods, and then hot pressing. Jiang Yuan Zhou and others scholars processed wood fiber by direct high-pressure steam, hemicellulose cemented can achieve performance thermoforming. Suchsland et al. (1985) obtained hot mill fiber by using a special method, through the use of wet, dry molding production process relies entirely on natural substances contained in the conversion of lignocellulosic pressed fiberboard. Xu Xinwu et al. (2011) researched that response from glued wood liquefaction interface mechanism to carry out in-depth research. These studies have formed a combined oxidation method, a radical initiator, acid catalyzed condensation polymerization, an alkali solution activation method, a natural substance transformation, activating method of six non-gel combination of theory, as no wood fiber glue gluing technology provides a theoretical basis. However, there is no glue glued wood fiber bonding strength, there are still insufficient, step cumbersome, inefficient and other defects, resulting in a self-bonded wood fiber processing techniques have not been applied on an industrial scale (Woch et al. 2015).

Bamboo is recognized as one of the most popular bioresources and is considered as a very sustainable resource. Bamboo is not a tree, but rather a type of grass that fully matures after 6-7 years, and can grow from the existing root structure even if its stalks are cut down. Bamboo is also diverse, commonly being used as a food source, as well as used to make a variety of household goods, such as furniture, sporting goods, dinnerware, jewelery, and handbags. Additionally, bamboo has been deemed a crop that could replace less sustainable crops in many areas to create a source of income, and has been a particularly important economic resource for poor people and families in China, as well as India. However, only about 40% of bamboo biomass is efficiently used in practice, and most becomes waste. Sustainability, industrial ecology, eco-efficiency, and green chemistry are guiding (Welfle et al. 2014). Bisso et al. (2014) reported that the development of the next generation of materials, products, and processes. Therefore, the aim of this study was to prepare bamboo composite material under various hot-pressing conditions and examine the chemical structure using FTIR, TGA, and differential thermal analysis (DTA).

MATERIALS AND METHODS

Materials

Bamboo, collected from Taojiang forest, bamboo scrap pieces and dry gas, a 40 to 100 mesh sieve bamboo powder, bamboo powder: 540 g. Under pressure 3.5 MPa format thermoforming sheet thickness is about 7 mm. Cellulose gum, the total mass of the addition amount of 1%, 3%, 5%, 7%. Melamine, 0.5 percent of the total mass of the addition amount, 1.5%, 2.5%, 3.5%.

Eperimental methods

In this research, the influence of various factors on the performance of the melamine bamboo cellulose gum is investigated by orthogonal test method, with the pressing temperature, pressing time, the added amount of cellulose gum, melamine dosage as factors. According to the orthogonal table $L_9(3^4)$ set up the test program, the number of samples in parallel is 3. The specific test factors and levels are shown in Tab. 1.

Tab. 1: Hot pressing parameters and results of samples

Level	Cellulose gum ratio (%)	Ratio of melamine (%)	Temperature (°C)	Time (min)
1	1	0.5	110	5
2	3	1.5	120	7
3	5	2.5	130	9
4	7	3.5	140	11

TGA/DTA analysis

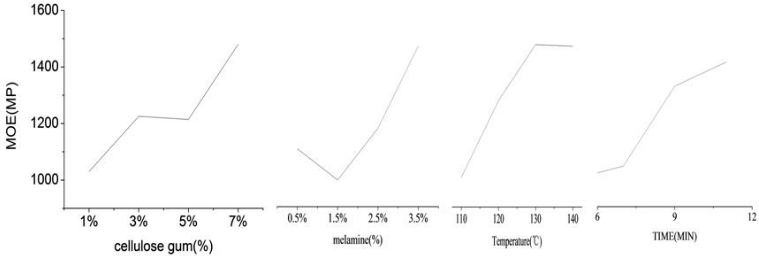
TGA study TGA (Perkin Elmer USA company, TGA / Pyris 6, temperature sensitivity: 0.01°C, mass sensitivity: 1×10-5 mg). Tested under high purity nitrogen atmosphere, sample control amount between 5.5 mg – 6 mg, particle size of 100 mesh or more at a heating rate of 10·min^{-1}, the pyrolysis temperature is 30°C to 800°C. Automatic data collection system, the process to obtain TGA data.

FTIR analysis

Crushing the sample by micro plant grinding machine, screening over 200 mesh powder, dried at 105°C to absolutely dry, put a dryer stored for later use. Select KBr (AR) as a background. Sample preparation to 10:1 ratio of powder mixed in repeatedly grinding glass mortar mix are hook, then take a little mixing well pressed powder pellet sample preparation, scanning the wave number scan range 4000~400 cm^{-1}.

RESULTS AND DISCUSSION

To visualize the reaction composite material preparation process, the relationship between the factors and mechanical properties of the process, it can be seen in the scatter plot : the amount of melamine is the main factor affecting the quality of physical and mechanical properties of the bamboo composite material, it has a significant impact on MOR board, internal bond strength, elastic modulus and other properties; cellulose gum is a secondary factor affecting performance; pressing pressure and pressing time have a certain influence on the performance of the board (Fig. 1).



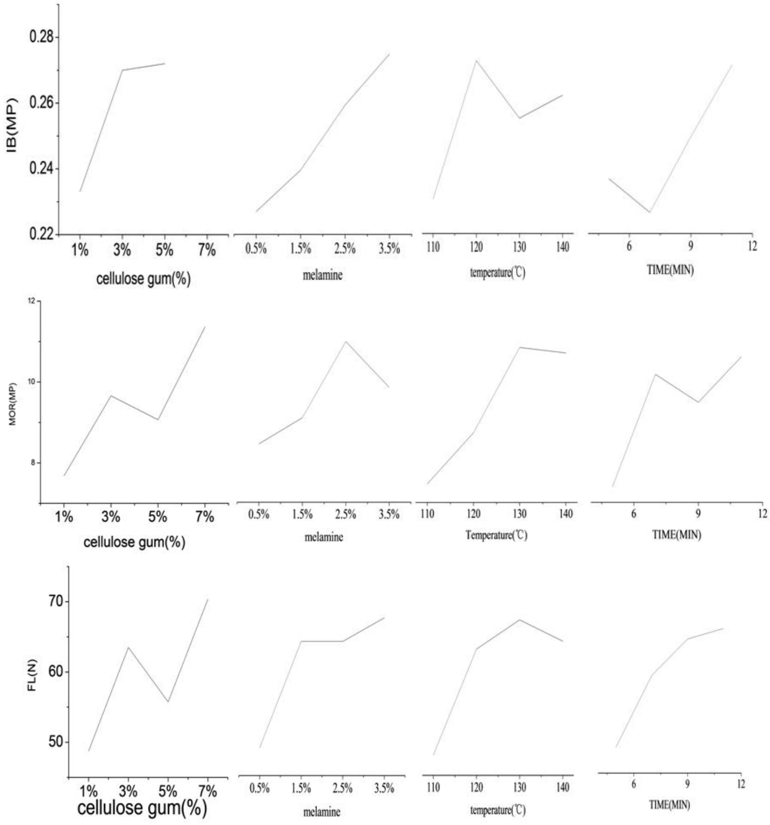


Fig. 1: Hot pressing parameters and results of samples.

TGA/DTG analysis

The applications of bamboo are very wide, especially in high temperature environments, so the thermal stability of bamboo composite materials research is of great significance. Within a specific temperature range, TGA is used to determine the weight of the sample changes. In controlled hot nitrogen atmosphere, bamboo and bamboo composite materials, the variety of reactions, leading to weight changes, including oxidation, reduction, decomposition and dehydration reactions. As shown above, the TGA and DTG curves, The bamboo composite sample H6, H10, H13, H14, H15, and H0 samples mainly experienced three stages (Fig. 2). The first stage is from room temperature to about 280°C, mainly bamboo composite material after absorbing the moisture evaporation stage, the chemical composition of the sample did not change; the second stage is about 280°C – 360°C temperature range of bamboo composite the main weight loss phase pyrolysis of wood, at this stage, the main bamboo composite material in the pyrolysis of hemicellulose and cellulose, and a small amount of lignin pyrolysis, accompanied by rapid weight reduction; the third stage is from 360°C – 800°C, 360°C after TGA curves bamboo composite leveling off, mainly pyrolytic lignin. At a temperature of 750°C, the samples H6, H10, H13, H14, H15 Weight loss was 70%, 80%, 70%, 68%, 60%, indicating that the bamboo composite with the increase of the temperature of the composite carbon residue of the sample increased gradually, possibly after high temperature composite, bamboo composite violent chemical reaction occurs, forming a number of refractory materials. The presence of lignin also increased char yield bamboo composite materials, mainly because of lignin added to improve the effect of carbonization bamboo biomass compound, resulting in an increase of the rate of carbon residue.

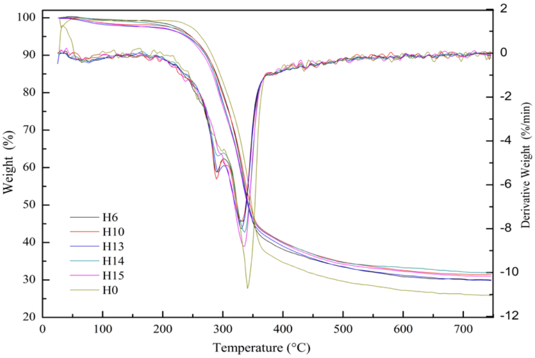


Fig. 2: TGA/DTG thermal curves of samples.

In addition, mainly the DTG curve weight loss, which represents the maximum degradation rate DTG_{max}, can be used to compare the thermal stability of the samples. As the raw material to increase the hemicellulose content of the material, DTG_{max} temperature fall, the samples H6, H10, H13, H14, DTG_{max} value H15 were 313°C, 333°C, 331°C, 335°C, 332°C. A comparative analysis indicated that the thermal stabilities of H6, H10, H13, H14, H15 and H0 samples increased gradually, which indicated that hot press obviously increased the thermal stability of these samples.

FTIR analysis

Infrared spectroscopy is typically used to study the functional group structure of bamboo and bamboo composite materials. IR spectra of the five samples as the table of Fig. 3.

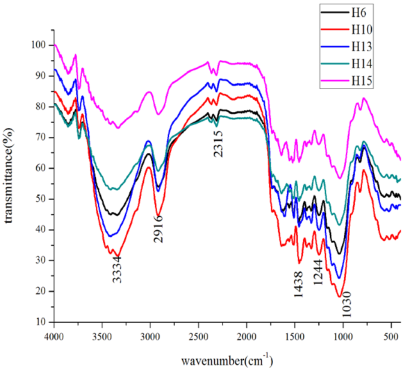


Fig. 3: FT-IR spectra of samples.

According to the literature available about bamboo at 3334 cm^{-1} is lignin and cellulose -OH stretching vibration, 2916 cm^{-1} is about methyl cellulose and lignin, methylene CH stretching vibration, 2315 cm^{-1} is about C≡N stretch (α, β-unsaturated aliphatic cyano) of the stretching vibration, 1438 cm^{-1} is about an aromatic skeleton stretching vibration, 1244 cm^{-1} is about Hemicellulose carbonyl and carboxyl (C = O) stretching vibration peak, 1030 cm^{-1} is about C-O, C-N stretching vibration fat. Infrared spectra of all samples have similar functionality, but the absorption intensity of each functional group is different. From the figure shows, the nearby -OH 3334 cm^{-1} peak stretching vibration absorption peak decreases gradually widened peak, peak displacement becomes small, indicating that pressing process increases the number of reactive hydroxyl groups, reactive hydroxyl groups can form hydrogen bonds, help to increase the strength of the bamboo plate; at 1244 cm^{-1} C-O-C formed, C-C stretching vibration has been enhanced, indicating that pressing process, the more intense hydrothermal synergy helps cellulose is hydrolyzed to produce more soluble aldehyde hydrolyzate in water. 2930 cm^{-1} be in a position of the transmittance decreases, the intensity of the absorption, methylene by the stretching vibration of CH, 1438 cm^{-1} is a characteristic absorption peak lignin aromatic ring, as described, the higher the temperature the wood participated in reaction yielded a stable compound; at 1244 cm^{-1} attributable to, methoxy CO stretching vibration. According to the changes of groups, cellulose gum ratio of 5%, ratio of melamine of 2.5% and the hot press time of 9 min were provided the optimum conditions for hot press.

CONCLUSIONS

In this paper, bamboo scrap as raw material by hot-press process for preparing melamine bamboo, with hot temperature, pressing time, the added amount of cellulose gum, melamine dosage factor test, orthogonal test method to explore the factors melamine the influence of properties of bamboo cellulose gum. The amount of cellulose gum is the main factor that affecting the mechanical properties of bamboo composite materials. MOR its board, elastic modulus, breaking load density and other properties have a significant impact; pressing temperature is affecting the performance of the secondary factors, MOR failure load significantly affected; the added amount of melamine have an impact on the performance of the board.

As the raw material to increase the hemicellulose content of the material, DTGmax temperature fall, the samples H6, H10, H13, H14, DTG_{max} value H15 were 313°C, 333°C, 331°C, 335°C, 332°C. It can be determined that the sample cellulose gum ratio of 5%, ratio of melamine of 2.5% and the hot press time of 9 min is better than other composites.

The use of bamboo for biomass resources to achieve energy conservation, protection of the ecological environment has important theoretical value and practical significance.

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