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To cite this article: Shengchao Zhang 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **233** 052031

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Study on the Preparation Process of Rice Straw Fiberboard for Packaging

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Abstract. The preparation technology of rice straw fiberboard was studied, the pretreatment and modification of rice straw were carried out, the bonding mechanism was analyzed, and the selection of adhesives and sizing technology were studied. Using rice straw fibers instead of wood to alleviate the shortage of wood raw materials, hot pressing to make rice straw fiberboard, focusing on the factors affecting the preparation of rice straw fiberboard, and optimizing the process parameters. Starting from the concept of packaging reduction design, this study provides data and theoretical support for the research and development of green packaging design materials.

1. Introduction

In the consumer market, people attach importance to product packaging, and look forward to the organic combination of packaging materials and ecological environment, so as to achieve the sustainable development of packaging. Rice straw fiberboard is a new packaging material, it can effectively avoid environmental pollution by widely using rice straw fiberboard in packaging design. In this paper, the preparation technology of rice straw fiberboard was studied, based on the theory of reduced packaging design in green packaging design.

The structure on physical and chemical properties of rice straw and wood are similar, after process setting, rice straw can be used to make fiberboard with packaging properties. The rice straw surface is rich in SiO₂ and smooth waxy layer, which hinders the chemical reaction of adhesives, it is impossible to produce rice straw fiberboard by using wood-based panel processing technology alone. Therefore, in the preparation process, rice straw fibers should be treated first, and the optimum design of adhesives sizing technology of the board should be carried out [1-3].

The rice straw was alkalinized, and the selection of adhesives and sizing process were optimized by orthogonal experiments. According to the theory of glue rationality, and the research on the chemical properties of straw surface, we think that the bonding strength can be effectively increased by applying isocyanate adhesive before urea-formaldehyde resin adhesive.

2. Pretreatment Technology of Rice Straw Fiber

The effect of alkali treatment on rice straw surface was observed by electron microscopy, and the optimum alkali treatment process of rice straw fibers was optimized by orthogonal experiment. The optimum pre-treatment process was adopted to improve the gluing property of rice straw surface, and the physical and mechanical strength of the board.

The straw surface treatment process is as follows:



2.1. Experimental material

- Rice straw: from Jilin Province, natural air-dried
- NaOH: AR, Solid content 96%
- Distilled water: common distilled water commonly used in laboratory
- Testing Instruments: Electric Heating Blower Dryer, DJH-24L-L, Shanghai Senxin Experimental Instrument Co., Ltd.

2.2. Pretreatment process

According to the previous research results of the research group, alkali concentration, solid-liquid ratio and treatment time were set. Configure alkali solution, mix the solution and rice straw fiber evenly according to the process settings, and stand at room temperature for 12 hours.

2.3. PH value setting of straw fiber

Previous experiments showed that the pH value and buffering capacity of straw had a significant effect on the gel and adhesive strength of adhesives. The optimum pH value is beneficial to the chemical reaction between rice straw fibers and urea-formaldehyde gum (after alkali treatment, the pH value of straw fibers is 10.5-11, the urea-formaldehyde adhesive is weak acidic, and the curing environment is 5-6, therefore, the pH value must be adjusted.), the optimized process is 1% hydrochloric acid.

2.4. Static and storage

Drying via temperature-control drier, moisture content is 1%~2%. After removal, the plastic bag is sealed and stored to prevent the absorption of moisture in the air. (To prevent cracking and bubbling of fiberboard during hot pressing with increasing moisture content).

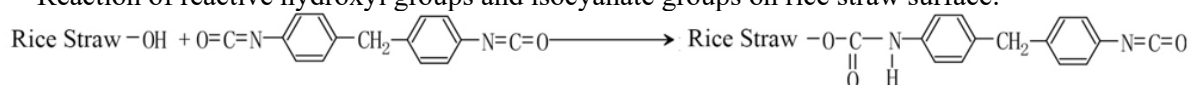
3. Bonding mechanism and selection of adhesives

3.1. Analysis of bonding mechanism

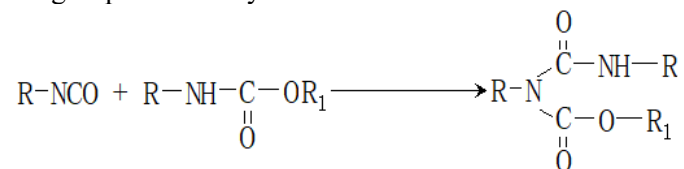
According to the analysis of chemical characteristics of rice straw materials, rice straw materials have a large number of hydroxyl functional groups, a smooth waxy layer on the surface of rice straw, separating the chemical reaction between urea formaldehyde gum and hydroxyl. Therefore, in the preparation of straw fiberboard, the use of low-cost urea-formaldehyde glue cannot achieve the purpose of gluing [4].

The isocyanate group of isocyanate not only reacts with hydroxyl group, it can also react with inactive ester bonds.

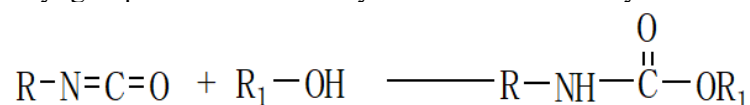
Reaction of reactive hydroxyl groups and isocyanate groups on rice straw surface:



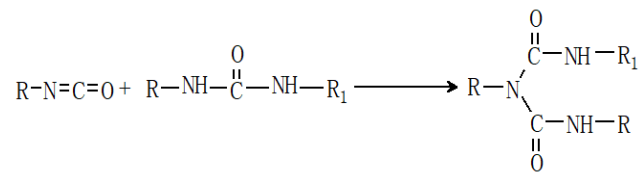
Reaction of isocyanate groups with waxy substances on rice straw surface:



Reaction of hydroxyl group in urea-formaldehyde adhesive with isocyanate:



Reaction of isocyanate with urea group in urea-formaldehyde adhesive:



3.2. Selection of adhesive and sizing method

Urea-formaldehyde resin is a common adhesive in fiberboard manufacturing industry, its characteristics are as follows: good process performance, moderate price and market competitiveness. Urea-formaldehyde resin is colourless after curing, and its bonding and moisture resistance are remarkable. However, because it is difficult for urea-formaldehyde resin to react with the wax layer on the straw surface and its bonding performance is not good, it is difficult to achieve the national standard of wood-based panels only by applying urea-formaldehyde resin [5].

The main components of isocyanate adhesives are isocyanate group (-NCO) and carbamate group, they have excellent adhesiveness and active performance. Isocyanate adhesives can react with rice straw actively, and their bonding properties are outstanding. But if only isocyanate is applied, the activity is too strong, the reaction is difficult to control, and the market price is expensive.

According to the previous research results of our group, when the isocyanate sizing amount is 1.5% of the total weight of raw materials, we can get the standard rice straw fiberboard. Therefore, the selection of isocyanate and urea-formaldehyde adhesives can solve the problem of difficult gluing on the rice straw surface, improve the strength of the board, and reduce the cost of the board, making it competitive in the market.

Experiments show that in the preparation process of rice straw fiberboard, the use of isocyanate glue and urea-formaldehyde glue together can effectively achieve excellent bonding effect. The order of sizing adhesives: first apply isocyanate adhesives, then apply urea-formaldehyde resin adhesives. The principle of analysis is as follows: in the bonding process, the main function of isocyanate adhesives is to form a bonding layer between high activity isocyanate group and rice straw fibers, and then obtain a high strength bonding effect; the value of urea-formaldehyde resin adhesives is to bond isocyanate to achieve bonding.

4. Hot pressing process of straw fiberboard

The preparation process is as shown in figure 1.

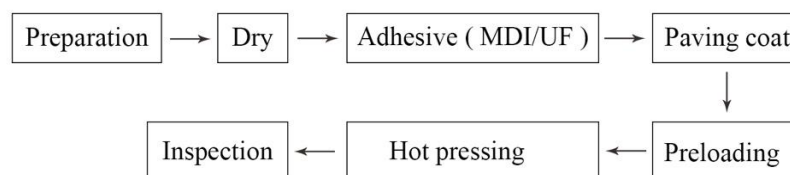


Figure 1. Figure with preparation process.

4.1. Preparation

Straw processing, cutting, screening part of earth, rock and sand to achieve cleanliness; alkali treatment.

4.2. Dry

Oven drying, 100 C, moisture content 2 ~ 4%.

4.3. Adhesive

- Apply quantitative MDI, stir the raw materials evenly.
- Apply quantitative UF, stir the raw material evenly.
- Add curing agent and paraffin, stir raw materials evenly.

4.4. Paving coat

The slab is paved according to the requirements of production technology, moisture content of 12%. The density of the prepared straw fiberboard is the same, that is, the expansion and shrinkage of the fiberboard are the same, which can effectively avoid the deformation and warping in the later processing.

4.5. Preloading

Room temperature, 1.5 MPa, 20-30 S, to prevent loosening and collapse.

4.6. Hot pressing

According to the design requirements, set the hot-pressing parameters and the hot-pressing curve, the adhesive is fully cured at a predetermined time.

4.7. Inspection

Cooling, constant temperature and constant weight (balance of temperature and water content), trimming, cutting, physical and mechanical properties test.

5. Conclusion

The structure and physical and chemical properties of rice straw and wood are similar, after technological setting, they can be used to make fiberboard with packaging properties. The rice straw surface is rich in SiO_2 and smooth waxy layer, which hinders the chemical reaction of adhesives, it is impossible to produce rice straw fiberboard by using wood-based panel processing technology alone. Experiments show that in the preparation process of rice straw fiberboard, the use of isocyanate glue and urea-formaldehyde glue together can effectively achieve excellent bonding effect. The order of sizing adhesives: first apply isocyanate adhesives, then apply urea-formaldehyde resin adhesives. The principle of analysis is as follows: in the bonding process, the main function of isocyanate adhesives is to form a bonding layer between high activity isocyanate group and rice straw fibers, and then obtain a high strength bonding effect; the value of urea-formaldehyde resin adhesives is to bond isocyanate to achieve bonding. The hot-pressing process of rice straw fiberboard should be pre-pressing and then hot-pressing, which can fully solidify the adhesive. The thickness of sheet can be set according to the requirement of product packaging, which can be used in packaging design

Acknowledgments

The authors gratefully thank the financial support by "13th Five-Year" social science research and planning project of Jilin Provincial department of education (JJKH20170988SK)

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