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Based on colorimetric indicators and dye uptake study of pretreatment on wheat straw for dyeing

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ABSTRACT

Ultrasound-assisted conditions at low temperatures dipping, select the dyes, direct dyes, reactive dyes, basic dyes, on different pretreated wheat straw dyeing test, comparative analysis of according colorimetric indicator and dyeing rate, research effects of different pretreatment methods on wheat straw coloring, screening suitable type of dye and pretreatment processes, and for dyeing mechanism by SEM analysis. The results showed that: Reactive dyes are ideal dye for wheat straw under low temperature conditions. The best pretreatment process as straw is 1% NaOH, 50^0C, 45 KHz, 60min The studies will development and utilization of straw resources to provide the necessary technical support, for the research and development of new composite materials and products of straw provide a theoretical basis.

KEYWORDS

Wheat straw;
Dyeing;
Colorimetric indicators;
Dye uptake;
Pretreatment.

INTRODUCTION

Dyeing process: Colorants (dyes, pigments, or chemical reagents) and dyed fabric between the physical adsorption and chemical reaction, so that the surface has a certain color fastness[1].

Straw dyeing can effectively improve the surface quality, improve their visual characteristics and increase the added value, deep processing of straw resources, comprehensive utilization of important research direction[2]. Selected direct dyes, basic dyes, reactive dyes, and dyeing test on pretreated wheat straw, hot dip dyeing. Computational analysis colorimetric indicators and dyeing rate SEM analysis, preferably the best dyes and dyeing straw pretreatment, screening suitable dyes and pretreatment process for straw[3-4]. Dyeing process to provide technical support for the development and utilization of straw resources, for the research and development of new composite materials and products of straw provide a theoretical basis[5-7].

MATERIALS AND METHODS

Materials preparation

Wheat straw was obtained from outside Harbin City, Heilongjiang Province, China. Natural gas to dry eight months after the harvest, removal of leaves, leaf sheaths, the interception of the color white, light, soft texture, and thickness uniformity of the stem, length of 15cm.

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Drugs and equipment

1) Dyestuff

Direct dyes - direct acid proof scarlet 4BS ($C_{35}H_{25}N_7Na_2O_{10}S_2$); Basic dyes - basic Red 1 ($C_{28}H_{31}N_2O_3Cl$); Reactive dyes - reactive Red X-3B($C_{19}H_{10}C_{l2}N_6O_7S_2 \cdot 2Na$), Dye Chemical Co., Ltd. Tianjin, CHINA;

2) Drugs

NaCl, Na_2CO_3, $NaHSO_3$, CH_3COOH, NaOH, AR. Hengxing Chemical Reagent Co., Ltd. Tianjin, CHINA;

3) Instrument

Triband CNC ultrasonic cleaner, KQ-200VDE, Kunshan Ultrasonic Instrument Co., Ltd. CHINA; Handheld spectrophotometer NF333, NIPPON DENSHOKU, JAPAN; UV-Vis spectrophotometer, TU-1800PC, Purkinje General Instrument Co., Ltd. CHINA; Environmental scanning electron microscope (SEM), Quanta 200, FEI, USA.

Experimental procedures

1) Pretreatment

Wheat straw surface contains a lot of waxy material and silica, Not easy to be dyed, explore the same time of Suitable dyes, Comparative analysis of different pretreatment methods on dyeing effect, optimization of Dye types and pretreatment process. Conditioning regimen shown in TABLE 1.

TABLE 1 : Process of pretreatment (Test material: Wheat straw)

No.	Pretreatment
Pre-A	No
Pre-B	1% NaOH, 50℃, 45 KHz, 60min
Pre-C	(1% NaOH, 50℃, 45KHz, 60min) +(3% $NaHSO_3$, 40℃, 45KHz,60min)
Pre-D	3% $NaHSO_3$, 40℃, 45KHz, 60min

2) Dyeing

Ultrasound-assisted conditions at low temperatures dipping. After dyeing, determination of dye uptake rate by UV spectrophotometry; Each experiment was measured after the straw surface color characteristics use spectrophotometer, according to the comparative analysis of color indexes and the dye uptake rate inspected the effects of different pretreatments on the staining effect, preferred suitable dye for wheat straw and suitable pretreatment[8]. Dyeing process carried out in accordance with conventional.

3) SEM analysis

Dyed straw cut out by transverse plane, production slices, observation studies of Image using Quanta 200 environmental scanning electron microscope (SEM).

RESULTS AND DISCUSSION

Analysis of chromaticity index

NF333 portable spectrophotometer for color measurement, using the International Commission on Illumination CIE L*a*b* (1976) color system table colors and computing color. Substrate surface chromaticity index L*, a*, b* values, respectively, the determination of each group of experiments, colorimetric index of each group were six samples for each group, measurements average out[9]. Other color values calculated as follows:

$$\Delta a^* = a^* - a^* s \quad (1)$$

$$\Delta C^* = C^* - C^* s \quad (2)$$

$$C^* = (a^{*2} + b^{*2})^{1/2} \quad (3)$$

$$\Delta E^* = [(L\,\text{After} - L\,\text{Before})^2 + (a\,\text{After} - a\,\text{Before})^2 + (b\,\text{After} - b\,\text{Before})^2]^{1/2} \quad (4)$$

With three red dyes selected wheat straw were tested. Calculate: Red and green axes chromaticity index difference Δa*, color saturation difference ΔC*, color difference ΔE *. The test results were shown in Figure 1.

As shown in Figure 1, under the same pretreatment

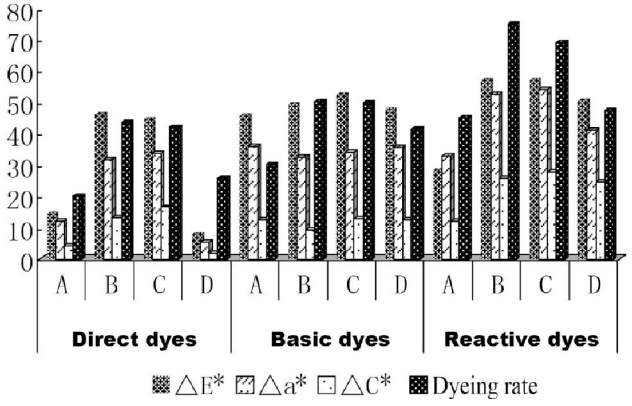

Figure 1 : Dyeing effects of three red dyes on wheat straw

conditions (B, C, D), reactive dyed straw of ΔE *, Δa *, ΔC * value than direct dyes and basic dyes to be high, pretreatment Pre- B: Δa * values were 31.9,32.38 and 52.66, ΔC* values were 13.33, 9.41 and 25.76, ΔE* values were 46.27, 49.52 and 57.31, high values indicate good dyeing effect, analyze the reasons: after pretreatment, removed some of the surface layer of wax.

Analysis of dyeing rate

Dye uptake via determined by UV spectrophotometry, the test results were shown in Figure 1. Dyeing rate is calculated as:

$$\text{Dyeing rate}(\%)=[(A_0-A_1)/A_0]\times 100\% \quad (5)$$

A_0 is the absorbance of dye before dyeing; A_1 is the absorbance after dyeing dye residue.

As shown in Figure 1, dyeing rate showed an increasing trend in varying degrees, in the same pretreatment conditions, activity of the dye is higher than the direct dyes and basic dyes: in pre- B, activity of the dye was 75%, and direct dyes and basic dyes dyeing rates were 43.71% and 50.12%. Description reactive dyes dyeing rate is higher than the other two-dyes, indirectly shows dyeing effect better than direct dyes and basic dyes. Analyze the reasons for the reactive dye more easily with straw fibers play a role, making straw absorb more dye molecules.

Choice of pretreatment

Reactive dyes dyeing effect is ideal for wheat straw, we can comparative analysis of different pretreatment methods on wheat straw coloring effect in Figure 1.As can be seen from the Figure 1, Pre- B and Pre- C treated wheat straw dyeing effect similar, taking into account the Pre-C is a two-step process, there may be a waste of resources, so choose the pretreatment Pre-B, stained straw optimal pretreatment method is 1%NaOH, 50°C, 45KHz, 60min.

Analysis of SEM

As shown in Figure 2-(a), wheat straw outer surface smooth and compact, "seam"-shaped pores clear, epidermal stratum corneum, analysis protoplast secretion horny, penetrate the cell wall and the formation of horny, mostly higher alcohols and higher fatty acids generated aliphatic compounds (wax), during the growth of the straw, effectively suppress evaporation of water inside and the intrusion of bacteria, hinder gum drops and the organic solvent wetting, diffusion, penetration[10].

As shown in Figure 2-(b), after Pre-B, sodium hydroxide treatment, alkali-soluble esters, wheat straw

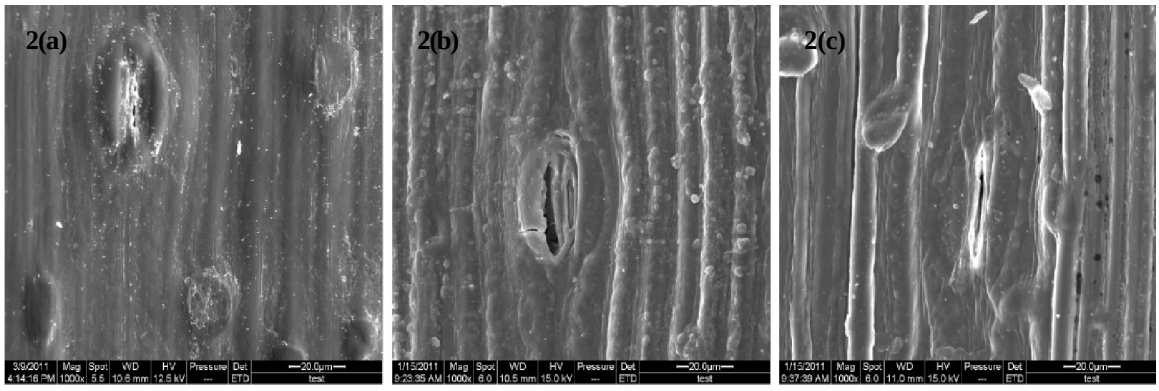

Figure 2 : Before and after the dyed of exterior surface of wheat straw (SEM)

smooth surface wax is removed, stomata opening obvious swelling and the edge of breakage phenomena, which are for the dye wetting, spreading and penetration created favorable conditions, uneven surface of the straw, a phenomenon similar to "etch."

As shown in Figure 2-(c), after Pre-B and dyed, wheat straw outer surface becomes rough, stomata closure, dye molecule aggregation, the adsorbed to the spherical shape, stomata closure was significantly blocked race, analysis: dye penetration or combination.

CONCLUSIONS

For wheat straw materials, Pre-B reactive dyeing, the surface of ΔE*, Δa*, ΔC* were 57.31,52.66 and 25.76, dyeing rate is 75%, value greater than direct dyes and basic dyes, and its color is more bright, in the dyeing process, the dye amount of dye to the fibers is higher;Compare a comprehensive analysis of the remaining pre-treatment process, stained straw pre-B is

optimal pretreatment method; Pre- B can effectively remove wax on Surface of wheat straw, while stomata opening, obvious and edge breakage phenomena, which are for the dye wetting, spreading and penetration created favorable conditions, SEM analysis shows, after staining dye molecule aggregation, stomata closure was significantly blocked race, analysis of dye penetration, or dye combination with wheat straw fibers. The above analysis and studies shows: reactive dye is the best dye on wheat straw;The Pre- B treated wheat straw best material for the dyeing;The best pretreatment process as straw is 1%NaOH, 50°C, 45KHz, 60min.

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REFERENCES

[1] T.Robinson, B.Chandran, P.Nigam; Effect of pretreatments of three waste residues, wheat straw, corncobs and barley husks on dye adsorption. Bioresource Technology, **3**, 119-124 **(2002)**.

[2] Lifeng Yan, Fan Yang, Lin Jia; Preparation of cationic wheat straw and its application on anionic dye removal, Journal of Biobased Materials and Bioenergy, **3**, 205-212 **(2009)**.

[3] S.McIntosh, T.Vancov; Optimisation of dilute alkaline pretreatment for enzymatic saccharification of wheat straw. Biomass and Bioenergy, **3**, 3094-3103 **(2011)**.

[4] Fakin Darinka, Ojstršek, Alenka; Colour of flax fibres in regard to different pretreatment and dyeing processes. Coloration Technology, **3(4)**, 216-222 **(2008)**.

[5] Bowyer, Jim. Wood and other raw materials for the 21st century. Forest Products Journal, **45**, 17 **(1995)**.

[6] T.M.Maloney; The family of wood composite materials. Forest Products Journal, 46, 18-19 **(1996)**.

[7] Jianping Sun, Fenghu Wang, Yingcheng Hu, et Al. Optimization design of panels made by crop straw based on genetic neural network. Transactions of the CSAE, **26**, 319-323 **(2010)**.

[8] Xiaodong Zhu, Fenghu Wang, Yu Liu. Properties of FRW Fire-retardant Straw-based Panels.Journal of Northeast Forestry Universiry, **37**, 84-86 **(2009)**.

[9] N.Boquillon, G,Elbez; Schonfeld U.Properties of wheat straw particleboards bonded with different types of resin. The Japan Wood Research Society, **50**, 230-235 **(2004)**.

[10] Stark, Nicole M.Mueller, A.Scott; Improving the color stability of wood-plastic composites through fiber pre-treatment. Wood and Fiber Science, **40**, 271-278 **(2008)**.