Study on Extracting Natural Plant Dyestuff by Enzyme-ultrasonic Method and its Dyeing Ability

Wen-Jing Liu, Yong-Zhu Cui*, Lei Zhang, Sen-Fang Ren

School of Textile Engineering & Light Industry, Dalian Polytechnic University, No. 1 Qinggongyuan, Dalian, Liaoning, 116034, China

***Abstract*:** The natural colorant was extracted from cortex phellodendri and rubia using biological enzyme and ultrasonic technology together, and the effect of biological enzyme and ultrasonic technology on natural plant dyes extract yield was discussed through absorbance values of extracted solution in this work. Also, the dyeing solution (cortex phellodendri and rubia) extracted by enzyme-ultrasonic method was found to give the highest color difference (ΔE) among dyed fabrics. It was proved through the experiment that, natural plant dyes extract yield can be increased by using biological enzyme and ultrasonic technology together, with high efficiency, energy saving and pollution dipping features. The optimized condition for dye extraction was to extract the dry cortex phellodendri and drubia at 50℃ for 60 mins. with pH 4.5.

***Keywords*:** Enzyme, ultrasonic, natural dyes, extracts, cortex phellodendri, rubia.

1. Introduction

The coloring of textile, wood, leather and other natural commodities with dyes from plants and other natural products is receiving increasing attention. What attracts people to textile colored with natural plant dyes may be due to one or a combination of factors. Natural plant dyes are based on nature and have small impact on environment during dyeing process. Many natural dyes are from Chinese medicine resources, have high officinal value and beneficial to human body such as cortex phellodendri and rubia used in this work. Therefore, it is an inevitable trend that natural dye will replace chemical dye, there are many reports about studies on natural dyes [1-4]. Generally, the natural dye should be extracted before dyeing process. Currently the extract technology includes water extract, drying method, heating drying, ultrasonic, enzymatic, etc. The traditional extractions, such as water extract, heating drying method causes a certain environmental pollution and numerous energy consumption due to the organic solvent used in separation and purification for extraction process, so the clean extract technologies such as biological enzyme and ultrasonic method are most popular. Biological enzyme functions at the plant's material surface, destructs cell wall, reduces the resistance of extracting colorant from the cells, so as to improve the extract yield, with low temperature, high purity and less pollution character. Ultrasonic method is a broken method. Ultrasonic wave stays in plant cell longer and deeper than what an electromagnetic wave can penetrate, and the effective components of the plant can be extracted easily [5]. In recent years, there are many reports on extracting natural dyes by enzyme or ultrasonic method. Zhao YH extracted anthocyanin in indigo slag with cellulase and pectase by enzyme hydrolysis extraction method [6], it was found that the extract yield by adopting composite double enzyme hydrolysis was 3.05 and 1.53 times higher than cellulase and pectase used by itself respectively. Cai J researched the application of enzyme in lycopene extraction process [7], the result was that, extract time can be reduced by adding pectase and cellulose simultaneously. Qiu B, et al. compared water extract and pectase by adding in the extract process of gardenia yellow [8], the conclusion was, the extract yield of gardenia yellow with the presence of pectase was higher than that of traditional extraction. Zhao CL extracted lycopene from fresh tomato by auxiliary function of ultrasonic extraction [9], the content of lycopene in the extracted solution was 55.72mg/100g under the optimum process by ultrasonic method. Wang B, et al. extracted capsicum red by ultrasonic method [10], it was found that the extract yield of capsicum red reached 10.68%, with less pollution, short time, high yield and purity. Jiang SJ et al. studied the process of extracted orange peel dyestuff by ultrasonic technology [11], finally it was confirmed that, ultrasonic extract method was much more excellent than traditional process. According to the researches above we can see, both enzyme and ultrasonic technology are able to increase the extract

*Corresponding author's email:yjcui1108@yahoo.com.cn
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yield in the extracting process of natural plant dyestuff, but there is litter report on extracting natural dye by enzyme/ultrasonic technology. In order to increase the extract yield, we chose enzyme – ultrasonic method to extract cortex phellodendri and rubia and studied various factors in the extract process, which improves the extract efficiency and saves energy at the same time.

2. Experiment

2.1 Materials and Agents

Samples of knitted fabric made of 100% cotton (32s, single) supplied by Dalian Puqi Knitted Co., Ltd (China) were used. Dried cortex phellodendri and rubia (China) were chosen. Cellulase was provided by Zhaodong Richeng enzyme agent Co., Ltd (China). Citric acid and sodium citrate (China) were grade of purity.

2.2 Instruments

Ultrasonic instrument (KQ2200E, 50Hz, 220V) was made by Kunshan ultrasonic Instrument Co., Ltd (China). Color difference meter (ADIC-60-C) (China) was provided by Beijing Chentaike Co., Ltd (China). UV spectrophotometer instrument was provided by The American PerkinElmer Co., Ltd.

2.3 Extract Process

2.3.1 Extraction Process of Cortex Phellodendri and Rubia by Enzyme Method

Citric acid (2.1g) and sodium citrate (2.9g) were added into water (100g) and a citric acid-sodium citrate buffer solution was prepared, the pH range was adjusted to 3.5-4.5. Cortex phellodendri and rubia were washed and dried, then cortex phellodendri/ rubia was added into water in material-liquor ratio 1:50, and then the mixed solution was stirred for 60min at 50℃.

2.3.2 Extraction Process of Cortex Phellodendri and Rubia by Ultrasonic Method

Cortex phellodendri/rubia was added in water with a material-liquor ratio of 1:50.Then the solution was heated and extracted from an ultrasonic instrument for 60min at 50 ℃. The extracted solution was centrifugally separated and clear solution at the top of the liquor was used.

2.3.3 Extraction Process of Cortex Phellodendri and Rubia by Enzyme-Ultrasonic Method

Cortex phellodendri/rubia was added in water with a material-liquor ratio of 1:50, then cellulose (0.04g) was added. Then the mixed solution was heated and extracted from an ultrasonic instrument for 60min at 50 ℃. The extracted solution was centrifugally separated and clear solution at the top of the liquor was used.

2.3.4 Extraction Process of Cortex Phellodendri and Rubia by Water Extract Method

The process was the same as 2.3.3, besides not applying ultrasonic technology.

2.4 Measurement of Extracting Yield

Ultraviolet spectrum instrument was taken to measure the absorbance of extracted solution and evaluate the extracting effect of different methods.

2.5 Optimized Extraction Process of Cortex Phellodendri and Rubia

The effect of temperature, time and pH value on extraction of cortex phellodendri and rubia were determined by evaluating the absorbance values of the extracted solution.

2.6 Evaluation of Dyeing Properties

The cotton fabrics were dyed with the solution extracted by water extract, enzyme, ultrasonic and enzyme-ultrasonic method, respectively. The color difference between dyed samples reflected the extraction yield, indirectly. Color difference ΔE was measured by color difference meter ADIC-60-C under illuminant D65, with a 10° standard observer. The corresponding CIE L*, a*, b* and ΔE were valued and compared with the blank sample.

3. Results and Discussion

3.1 Extraction Yield of Cortex Phellodendri and Rubia by Four Different Methods

In order to compare the extraction yield of four different methods, cortex phellodendri and rubia were extracted in that order in this experiment. It can be found from Figure 1 and 2 that, enzyme-ultrasonic