2023 年臺灣國際科學展覽會
優勝作品專輯

作品編號　100008

參展科別　工程學

作品名稱　朽木生花-初探以中藥萃取液對木材染色之防蟲抑菌效果

得獎獎項　四等獎

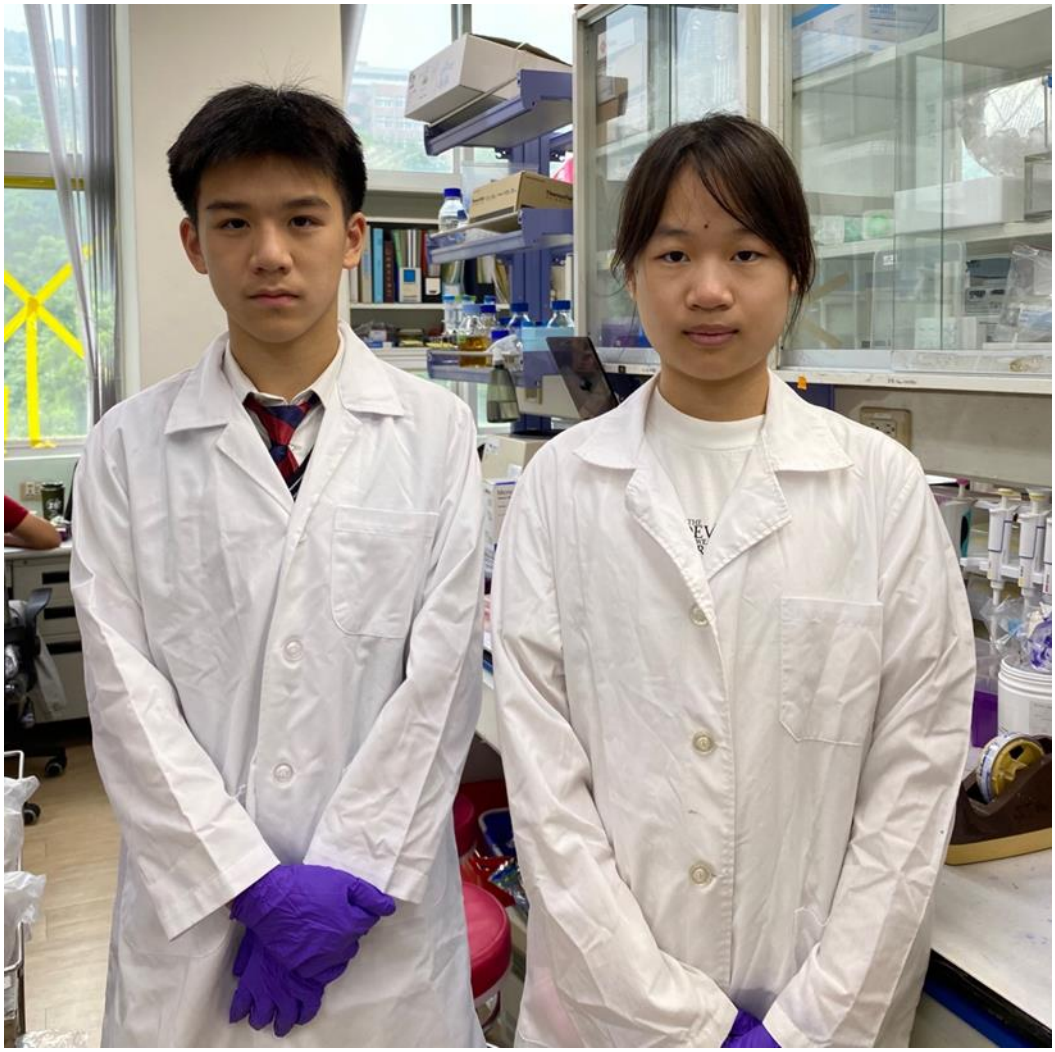
就讀學校　臺北市私立復興實驗高級中學
財團法人臺北歐洲學校

指導教師　彭黃銘、Yoko Tsai

作者姓名　何定澤、黃鳳綺

關鍵詞　Radiata pine、Termite、
Traditional Chinese medicine

作者簡介



我是何定澤，對生活充滿好奇樂於研究學習新事物，喜歡游泳暢快自得，西洋棋果敢挑戰，更喜歡閱讀並享受實驗過程中探索未知，夢想能運用科技改善人類疾病及生存環境，隨時學習新知與世界接軌，持續努力實踐夢想。

我是黃鳳綺，一位 14 歲充滿學習熱忱的學生，除了巴西柔術和實驗解剖等愛好外，我對生物、化學和數學等學科都充滿熱情。 我喜歡藉由學習過程而獲得信心並保持積極的心態。 此外，我喜歡生物相關實驗，未來期望藉著我的學術研究，能與世界分享充滿前景的學術貢獻。

Abstract

In our experiment, we used traditional Chinese medicine to dye on cheap wood, in addition to avoiding the impact of chemical paint on human body. After dyeing, the color and texture quality of the wood are improved, which makes cheap wood gain a higher price and improves the value. At the same time, it can reduce the felling of slow growing precious wood, which has the functions of environmental protection, earth love and carbon saving.

The test material was pretreated with hydrogen peroxide and surfactant, and the bleaching effect was obvious. After dyeing with different Chinese medicinal materials, soak in strong acid and alkali solution for 15 minutes, which shows that strong acid and acid treatment is not allowed. In addition, after 15 minutes of immersion in detergent, the color difference value is less than 2, and the rubbing fastness is above grade 4. In the bacteriostasis experiment, no fungus grew in the first 3 days, and it did not grow in the 12th day. In the anti-termite experiment, the mortality rate on the fifth day was 65% for Lithospermum and 83.8% for Wolfberry; the other groups had a good effect of total elimination.

While plastic products have a great impact on the environment, the environmental value of wood that is dyed or modified with natural colored substances, far exceeds the human visual perception.

I. Preface (including research motivation, purpose and literature review)

1、 Research motivation

People who like natural materials pursue to fit with nature, and they also use natural materials in their living environment. Materials originated from the ancient times. Under the guidance of Youchao, ancestors moved from the original caves to building their own houses. Wood was beginning to be incorporated into people's living habits. Wood cannot be separated from food, clothing, housing, and transportation. When people began to use wood, they found the problem of insects and mildew, these problems need to be overcome with chemicals, the most serious cases requiring formaldehyde. According to the prevention and rescue manual prepared by the Professional Consultation Center for Environmental Accidents, "the patient can endure 10 to 30 minutes at 4 to 5 ppm, and the discomfort increases greatly when the score exceeds 30 minutes. At 10 to 20 ppm, the patient has difficulty breathing, and the nose, pharynx, and trachea feel hot, and coughing is induced. 50 to 100 ppm can cause serious injury. High concentrations can cause pulmonary edema (symptoms after several hours), pneumonia, or death." Wood dyeing can avoid the influence of chemicals on human beings.

The price of wood can range widely. There are many factors that affect the value of wood: strength, color, texture, and moisture absorption. This experiment is to improve the use and value of wood mainly. Improving the texture and aesthetic significance can meet the expectations of users.

Secondly, precious timber has become scarce after many felling. If we use wood dyeing as the substitute, we may supplement market needs, and slow down the disappearance of precious timber. Third, acid dyes or direct dyes are used in traditional wood dyeing. After dyeing, the wastewater must be treated to avoid environmental pollution. In our experiment, traditional Chinese medicine is used, including insect resistant, and the pigment is extracted from medicinal materials. There is no wastewater treatment problem. In addition to reducing the cost, it is also beneficial to environmental protection.

2、 Purpose

This experiment was conducted using the cheapest white pine logs after inquiry. The choice of Chinese medicinal materials was consulted by a senior Chinese medicine doctor. The main consideration is to use medicinal materials that are soluble in water and beneficial to the human body. The purpose of this experiment is as follows:

（1） Experiment 1: Wood pretreatment

（2） Experiment 2: Moisture absorption of wood and changes after drying

（3） Experiment 3: Discuss the dyeing fastness of wood after dyeing

（4） Experiment 4: Discuss the bacteriostatic effect of wood dyeing

（5） Experiment 5: To explore the anti-termite effect of herbal extract

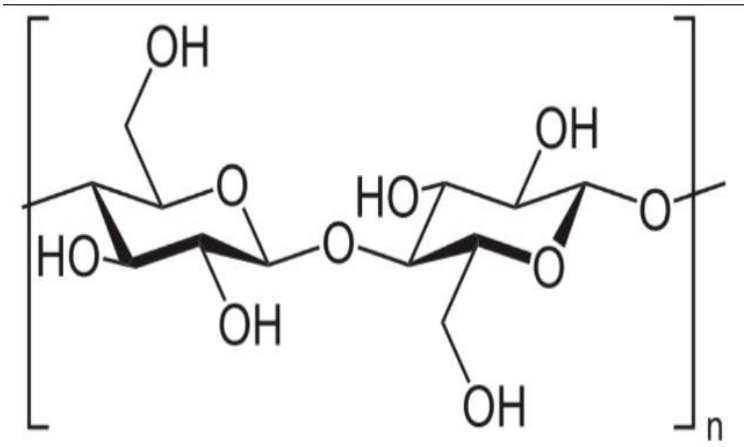
3、 Literature review

（1） Wood Dyeing of Tea Extract (94.6.22 Master's Thesis, Department of Wood Industry, Pingtung University of Science and Technology)

This is the only report on wood dyeing in the National Library. Its starting point centralizes environmental protection as the theme, abandoning the traditional use of chemical dyes, and using commercially available black tea and green tea. After extracting them with hot water, concentrate them into 1%, 2%, and 3%, and then dye them at 30 minutes and 60 minutes of boiling and room temperature, respectively. In this experiment, two kinds of mordant are used: copper sulfate and cuprous sulfate aqueous solution, they all contain copper ions, which are not environmentally friendly heavy metals. The dyeing effect used four kinds of wood: red oak, Chinese fir, spruce, and Selangan Batu is compared. It is considered that the solid wood that has been pretreated should be used. The pretreatment can reduce the impact of impurities such as pigment released by the plant itself when dyeing. The experiment found that the boiling method was better for coloring, and the higher the concentration of tea liquor, the longer the dyeing time, and the more effective.

The principle of wood dyeing: the main components of wood are cellulose, hemicellulose, and lignin. Wood dyeing is similar to the dyeing of cotton cloth. At present, the principle of hand-dyed works is the same as that of betel nut, banyan leaf, and onion skin. Because the pigments of Chinese medicinal plants are mostly polysaccharides or phenols, they have - OH group and - H bond, and they are easy to combine with the same structure of cellulose, so they can be colored. There are four steps in the dyeing process (Wang Huixiong, 1982):

A. Diffusion process: dye molecules diffuse from water to fiber surface.
B. Adsorption process: dye molecules are adsorbed on the fiber surface.
C. Diffusion process: dye molecules diffuse from the fiber surface to the fiber interior.
D. Fixation process: dye molecules are fixed by forming physical or chemical bonds with fibers.



From Wikipedia: https://healthjade.net/microcrystalline-cellulose/

There are many kinds of dyeing aids. Different metal ions coordinate with pigments. Because of different absorption wavelengths, their colors will be different. Therefore, non-heavy metal dyeing aids can be used. It is recommended that aluminum alum, table salt, etc., will not change color significantly under acidic conditions, and metal ion coordination and coloring can be achieved to increase their dyeing speed.

（2）Discussion on the elimination of active oxides and active nitrogen compounds by sixteen medicinal plants (the 12th master class of the Department of Chinese Pharmacy and Traditional Chinese Medicine Resources, 2012)

In this paper, the components of 16 medicinal plants in Taiwan were analyzed for antioxidant components (determination of total polyphenols, flavonoids and flavanols) Antioxidant capacity analysis (determination of total antioxidant capacity, DPPH free radical scavenging capacity, etc.). The experimental results show that the antioxidant activity of 16 groups of materials is related to the phenolic substances, so total polyphenols are the main components of antioxidant and anti-inflammatory. The selected restorative materials in this group have antibacterial and antiseptic functions. The following medicinal materials are collected from databases such as A Medical Encyclopedia, Medical Bian Shen Yao Zi, etc.:

A. Lithospermum: it can inhibit influenza virus in chicken embryos, delay cytopathic effect of poliovirus in tissue culture, and inhibit the immune response to hepatitis B antigen; Lithospermum has an inhibitory effect on Staphylococcus aureus, Escherichia coli, Salmonella typhi, Shigella dysenteries, and Pseudomonas aeruginosa. After boiling, it loses its antibacterial effect.
B. Gardenia: It has the functions of protecting the liver, sialagogic, lowering blood pressure, calming, hemostasis, detumescence, etc. It is commonly used in the clinical treatment of jaundice hepatitis, sprain and contusion, hypertension, diabetes, etc.
C. Turmeric: (1) Hypolipidemic effect (2) Anti-tumor effect (3) Anti-inflammatory effect (4) Anti pathogenic microbial effect (5) Impact on cardiovascular system (6) Cholagogue effect (7) Effect on termination of pregnancy (8) Antioxidant effect, other effects: Turmeric can kill flies.
D. Wolfberry: Modern medical research has confirmed that it contains betaine, polysaccharide, carotene, Vitamin A, C, B1, and B2, calcium, phosphorus, iron, zinc, manganese, and other nutrients, which can promote the hematopoietic function, and has the effects of anti-oxidation, tumor inhibition, hypoglycemia, and so on.
E. Tuber fleece flower.: It contains phenolic compounds. Its root contains corytophanid, emodin, and Rhein. It can detoxify, disperse stasis, and detumescence. It can also be used for the treatment of allergy, itching, constipation, and hyperlipidemia, and together with henna, it can be used as a plant hair dye.

F. Rehmannia glutinosa: The Rehmannia glutinosa polysaccharide contained in it has the following functions: obvious immunosuppression and tumor suppression, significant cardiotonic and diuretic functions, liver protection, hypoglycemic, antibacterial, and fungal effects.

（3）Evaluation of the application of Cornus Officinalis extract to termite resistance (Master's thesis of the Institute of Forestry Science and Furniture Engineering, College of Agriculture, Chiayi University)

In this paper, AWPAE1-97 woodblock test method is mainly used for the test of woodblock termite resistance: the method is properly improved, and the steps are summarized as follows: :

A. Place 100g of clean river sand with high-temperature sterilization in a flower gourd bottle as the culture medium, then add 20mL of distilled water and let it stand for 30 minutes to balance the humidity.
B. Put wood block: The wood block shall be close to the bottle wall for easy observation. After that, 100 termites were transferred to the flower gourd bottle for culture, with the ratio of soldier ants: worker ants=1:9, and the bottle cap was closed. Each group was repeated 3 times and put into the RH90% growth box at 25 ± 2 ℃ for 30 days.
C. After 30 days, take out the wood block from the flower gourd bottle, remove the sawdust on it, and place it in the oven to dry at 105 ± 3 ℃. Weigh the absolute dry weight and calculate the weight loss rate of the wood block and the mortality rate of termites.

（4）Study on the Antitermite Activity of the Ethanol and Water Extracts of Rhizoma Stemonae on Medicinal Plants (Department of Forestry and Furniture Engineering, Chiayi University, et al.)

The experiment was carried out in three ways, as follows: :

A. Test method for termite resistance: put 3 soldiers and 27 workers in a Petri dish (diameter: 9 cm; height: 1.5 cm). After taking the extract solution, place a round filter paper with a diameter of 5.5 cm in a petri dish with a diameter of 6 cm and a height of 1.5 cm, drop 1 mL of the extract solution, and make it completely wet on the whole round filter paper. After being placed for about 30 min to volatilize the liquid, add an appropriate amount of distilled water to moisten it, then put in 3 soldier ants and 27 ants, soldier ants: worker ants=1:9, cover the petri dish and place it in a growth box with a temperature of 25 ℃ and an RH of 90%. Observe and record the number of dead ants within 7 days. All treatments were repeated 3 times, and the nontreatment group was used as the control group. Results The mortality rate and filter paper weight loss rate were calculated according to the following formula:

   Termite mortality rate (%)=(number of dead termites/total number of termite tests) × 100%

B. Contact toxicity test method: drop the original extract solution into ADVANCE No.1 filter paper (about 1ml), wait for several hours to air dry the filter paper, add an appropriate amount of distilled water to moisten it, and calculate the mortality rate of termites after 14 days. Formula: Termite death rate (%)=(number of dead termites/total number of termite tests) × 100%

C. Repellent toxicity test method: It is similar to the steps of method 1. First, split the filter paper into two halves, and then drop the dissolved extract onto half of the filter paper, while the other half of the filter paper has no extract. After the filter paper is dried (2-3 hours), add an appropriate amount of distilled water to adjust the humidity. After 60 minutes, observe the average rate of termite repellency. The formula is as follows: termite deterrent rate (%)=[(B-S)/A] × 100% (B: Number of white filter paper termites; S: : the number of termites on the filter paper of the sample; A: Total number of test termites.)

   Four methods: one method is used because it is convenient to obtain termite test and can be more suitable for this group.

(5) The permeability of commonly used wood preservatives in Taiwan and the moldy phenomenon of treated wood (Master Class, Department of Forestry and Natural Resources, Yilan University, 2013). The three experiments in this group are the permeability test, moldy test, and performance comparison of the same type of copper alkyl ammonium preservatives. The records are very detailed, At the same time, this experiment refers to and compares the methods used in the article "Research on the pest and mold control technology of building materials

A. Preparation of test materials: the number of materials in the experimental group and the control group is three groups respectively.
B. Sterilization: sterilize with autoclave.
C. Culture: After drying and shaping, the test material is put into potato agar (PDA) plastic culture medium, and the test material sheet and PDA must be separated by U-shaped rod.
D. Preparation of fungus holding solution: drop several drops of sterile water into the culture dish full of fungi, sample mycelia or spores from the place where the culture medium grows and pour the water with fungi into the spray bottle containing sterile water as the cytosol suspension.
E. Fungal inhibition test: put the culture medium containing the sample in a sterile environment, spray the surface of the sample with an aqueous solution containing fungal spores with a spray bottle, fix the number of presses on each plate, seal it with a sealing film, and place it in a growth box at 28 ℃. After 4 weeks of storage, take it out to evaluate the anti-fungal effect.

II. Research process or method

1. Raw materials and medicinal materials:

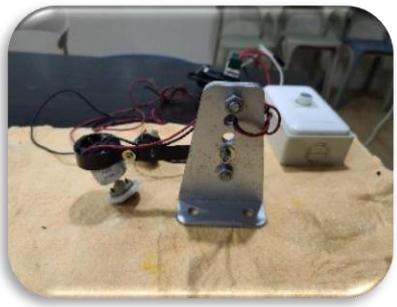
   Chinese herbal medicine, hydrogen peroxide, fatty alcohol surfactant, thermometer, cleaner, acid and alkali test paper, ADVANCE # 1 filter paper, pure water, Kanten Powder (agar), potato, glucose, cotton white cloth, double-sided adhesive tape.

2. Instruments and equipment:

   Dryer, induction cooker, beaker, stainless steel pot, 250ml serum bottle, iron clip, latex gloves, cotton gloves, sander, and coarse and fine sandpaper, pH meter, straw, heater, bag sealing, autoclave, precision scale, mortar, colorimeter, culture dish, ultraviolet (UV-C) bacterial lamp, eye protection glasses, curved straw, small paint brush, sprayer, scissors, shovel, screwdriver, adjustable light and dark switch of electric lamp, breeding box.

3. Fabricated by rubbing fastness machine：

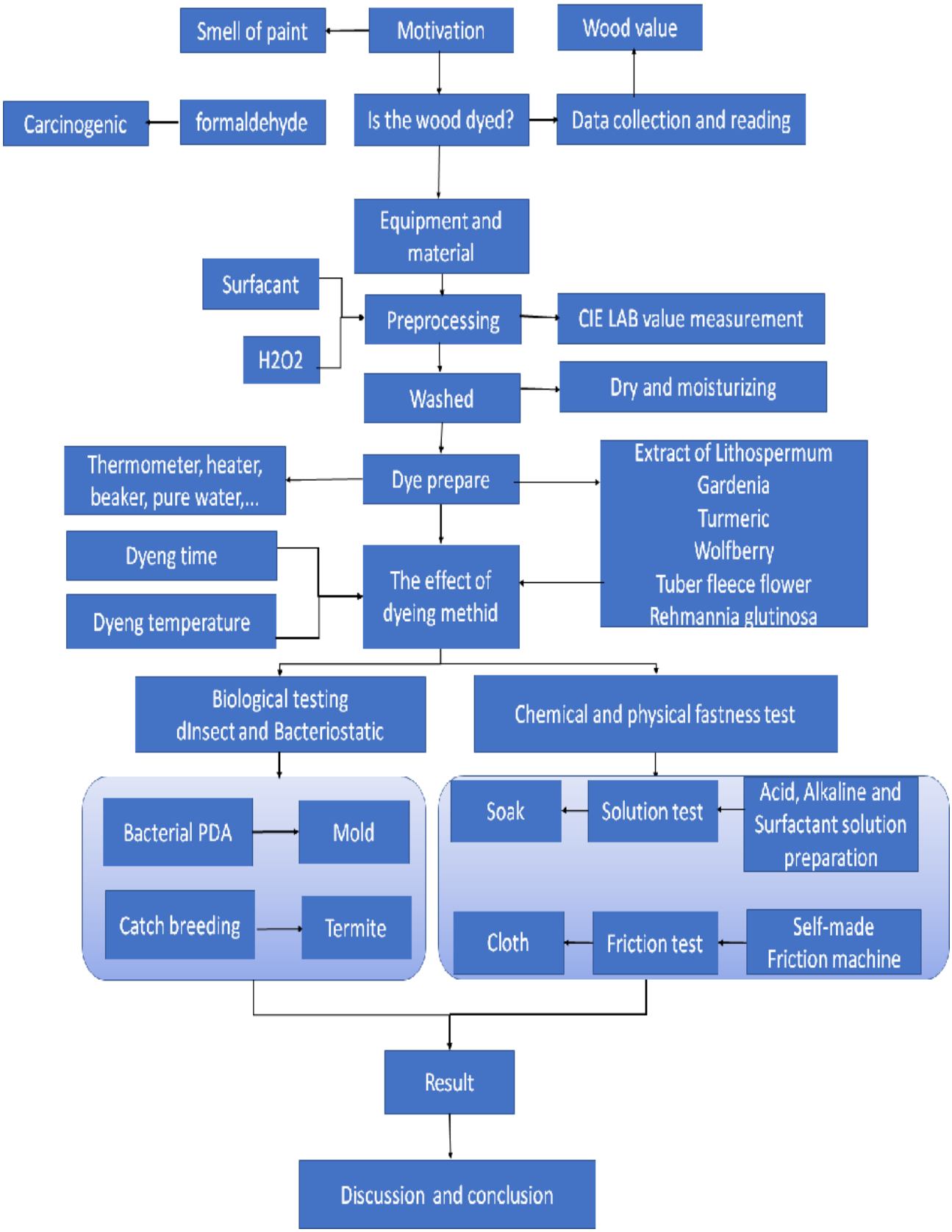
（1） Motivation description: dyed materials will have the problem of color fastness. Cloth often has fastness such as washing and rubbing. However, the fastness standard of wood after dyeing has not been set, so the fabric dyeing friction fastness machine is used as a reference; In this group, a self-made friction fastness tester was used to measure the dyeing fastness of wood chips fairly.



Principle: The motor uses 110V power supply, and gear is installed on the shaft. The weight of the motor plus the counterweight reaches 100g. Then the output current is controlled by the dimmer to fix the speed of the motor. The cloth is fixed under the round gear, and the dyed wood is placed under the friction wheel. The friction time is controlled for 1 minute.

（2） research process or method

Experimental process



4、 Experiment preparation

（1） Termite rearing

A. There are 4 families, 12 genera, and 17 species of Formosan termites. The termites in this experiment were taken from the rotten wood in the mountain area of Fangshan Township, Pingtung. They are also called Taiwan termites, Taiwan milk termites, and home termites. Their number is the largest on the island. The body color is translucent milky white, and the body shape is like that of the PET bottle; The ant nest is mainly composed of a queen, soldier, and worker ants.

B. Classification: insect net

Ptera

Isoptera

Rhinotermitidae

Termite

Formosan termite

raised in slightly wet wood chips and soil

C. Termites' food: cellulose mainly includes wood, plants, carpets, cardboard, gypsum board paper, cotton textiles, and animal excrement; According to the master's thesis of the Research Institute of the Department of Wood Materials and Design, National Chiayi University, "Investigation of the intestinal microflora and function of Formosan termites", the intestinal research of Formosan termites found that there were three kinds of symbiotic protoflagellates in the stomach of worker ants. Further analysis showed that there were a lot of combustibles in the intestine: alkanes, naphthenes, etc., which proved that Formosan termites could decompose cellulose. In addition, three types of gram-negative bacteria coexisted in the intestinal microbial culture; Because workers mainly act as foragers, more bacteria are found in the gut than soldiers. The strains isolated from the gut of the workers of Formosan termite, the Formosan termite, could decompose cellulose. This research is very important for the development of energy.

D. Habitat: This group observed that termites have negative phototaxis, do not like to see light, and move more slowly than ants. When catching them, they were moved away by smaller ants without paying attention. They prefer to live in groups in a slightly damp and warm dark environment with food. They can be found in decayed trees with a little attention.

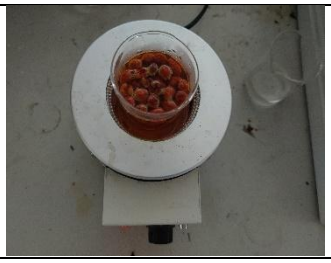
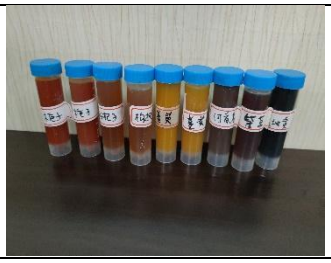
Open the mat to find termites

E. After the experiment, all termites were drowned in water. Open the mat to find termites

(2) Chinese herbal medicine extraction

A. Take 50 grams of each of the following medicinal materials, such as lithospermum, gardenia, turmeric, wolfberry, Tuber fleece flower, and rehmannia, and mash them with a mortar.

B. Place them in 250 beakers respectively, boil with 200 ml pure water for 30 minutes, filter with a filter screen, leave the boiled liquid, fill it into a 50 ml centrifuge tube, cool down and refrigerate for standby.

		
Lithospermum boiled	Gardenia boiled	Into 50 ml centrifuge tube

(3) Preparation of PDA medium:

A. Prepare a potato, wash it with water, weigh it, weigh it 100.0g, peel and cut it into pieces.

B. Add water (400.0g) 4 times the weight of potatoes and cook for 1 hour.

C. UV-C Sterilize the culture dish with UV-C lamp for 30 minutes.

D. Filter off the potato residue with a filter screen and add water to a fixed volume of 400ml.

E. PDA (liquid) culture medium: extract 100 ml of potato juice, add 10.0 g of glucose and 10.0 g of Agar powder, add water to the total volume of 600 ml, and stir it evenly with a glass rod.

F. Pour evenly stirred PDA culture medium into serum bottles respectively, with the bottle caps not fastened.

G. Put the PDA serum bottle into the autoclave to check the water volume and program settings and sterilize with steam.

H. After sterilization, when the temperature drops to about 50 ℃ (not hot but not solidified), spray 75% alcohol on the desktop to be sterile, and light an alcohol lamp around the operation area to sterilize.

		
Peel potato	Autoclave sterilization	Medium inversion

I. Pour the PDA culture medium into the culture dish and put it into the refrigerator for refrigeration after the culture medium is solidified.

（4） Preparation of acid and alkali aqueous solutions:

A. Use hydrochloric acid to prepare an aqueous solution with pH=4.

a. Take 37% hydrochloric acid with quantitative tube, volume=0.1 × 100 × 36.5 ÷ (1000 × 0.37 × 1.19)=8.3 ml hydrochloric acid is added into a 1000ml volumetric flask with a small amount of pure water, water is added to the scale line, and then shaken up to form a 0.1M hydrochloric acid aqueous solution.

b. Take 1ml of the adjusted 0.1M hydrochloric acid, then add 99ml of pure water to prepare 100ml of pH=3 aqueous solution. Then take 100ml of pH=3 aqueous solution and add 900ml of pure water to prepare an aqueous solution of hydrochloric acid with pH=4.

B. Use sodium hydroxide to prepare an aqueous solution with pH=13 and pH=10.

a. Dissolve 4.0g of sodium hydroxide in 1000ml of water to prepare 0.1M sodium hydroxide aqueous solution.

b. It is prepared by the same method as hydrochloric acid, pH=13, pH=10, sodium hydroxide aqueous solution.

C. After completion, confirm the pH value of the above aqueous solutions with an acid-base meter.

5、 Experiment 1: Wood pretreatment

（1） Material preparation: (experimental wood is purchased from Newpine of Nangang Shuncheng Construction Hardware Co., Ltd.)

Take 5 pieces of wood chips after cutting, weighing 385 g in total, and the proportion of wood chips to water is 1:10, so 3850 ml of bleach water solution is required to react, and the calculation is as follows:

A. Bleaching agent: dilute 642 ml of 30% hydrogen peroxide to 5.0% 3850 ml.

B. Aliphatic alcohol surfactant concentration: 5.0g/l, so 19.3 (g) is required.

（2） Handling:

A. Mix the above materials and place them in a 5L iron pot.

B. Add wood chips and soak them in the induction cooker at 65~70 ℃ for 15 minutes.

C. Take it out and drain it, and then test the surface of the material with a widely used test paper to make it nearly neutral.

D. Wash with clean water, drain twice, and dry in a dryer at 60 ℃.

E. Take photos in the standard D65 light source camera box; Then use Photoshop to measure Lab values at 5 different locations.

		
Warming up	bleaching	Camera box

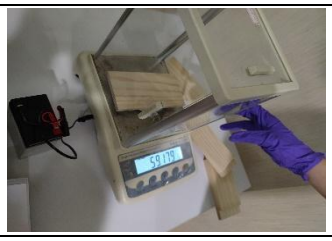
6、 Experiment 2: Moisture absorption of wood and changes after drying

（3）Immersion and measurement

A. Put five pieces of white wood into pure water, press heavy objects to make them completely immersed in water for 30 minutes, then take them out and drain them slightly.

B. Record the indoor temperature of the day. (With air conditioner, the average temperature is 26.5 ℃, and the humidity display is 55%)

C. Measure the weight with a precision balance every hour and record it.

		
Immerse in water	Dry indoor	weight

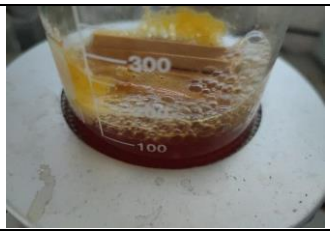
7、 Experiment 3: Discuss the dyeing fastness of wood after dyeing

（1） Wood preparation

A. Take the bleached dried wood and cut it into 100mm × 20mm × 5 mm strips and 20mm × 20mm × 10mm square size.
B. The sawn surface of the wood shall be polished with sandpaper.
C. Take 6 pieces from each group and 6 pieces from the control group, 42 pieces of strips, and 42 pieces of 20mm square.

（2）Staining

A. Take 100ml of each refrigerated Chinese medicine solution after extraction and place it in a 500ml beaker.
B. Heat at medium temperature to keep it slightly boiling and add wood chips and sticks to test.
C. Boil for 30 minutes, take it out and drain it, then place it in a dryer at 60 ℃ and dry it for 8 hours.
D. Clean the dried wood sample with clean water twice, and then dry it.

		
Boil for 30 minutes	Dry in the oven	After drying

（3）Influence of Acid and Alkali Aqueous Solutions and Interfacial Activators

A. Separate 200 ml of pH 4.0 hydrochloric acid aqueous solution and pH 10.0 sodium hydroxide aqueous solution.
B. Take 4.0g of detergent and prepare 200ml of 2.0% detergent aqueous solution.

C. Take the stained wood block and immerse it in the above three aqueous solutions and the pure water of the control group respectively for 15 minutes.

D. Wash and dry the wood block after the experiment.

		
Confirm pH Value	Soaking test	After washed

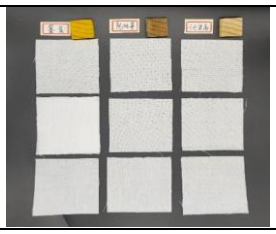
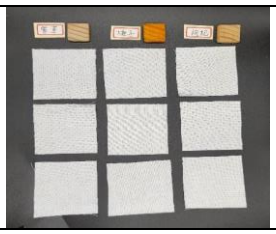
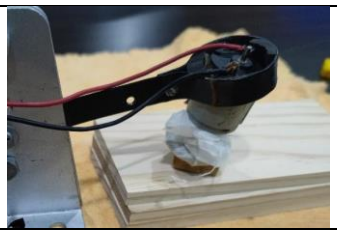
（4） Dye fastness test:

A. Cut the cotton cloth into 7 cm × 7 cm size. Repeat the experiment with 3 tablets in each group.

B. The cloth is tightly fixed on the friction disc with double-sided adhesive tape.

C. Place dyed wood under the friction disc and control the speed to 1 rpm for 1 minute.

D. after completion, take down the sample after the test and replace the sample to be tested.

		
Cloth preparation(1)	Cloth preparation(2)	Test condition

E. Determination of rubbing fastness:

The friction fastness is rated by the "grey sample card" according to five grades, with the first grade being the worst and the fifth grade is the best. Self-made color swatches: RGB represents the combined color of tricolor light, and 0-255 numbers represent the intensity of the three primary colors, which are combined into different color lights from all black to all white.

R=G=B=143	R=G=B=143	R=G=B=143	R=G=B=143	R=G=B=143
Lv 1	Lv 2	Lv 3	Lv 4	Lv 5

8、 Experiment 4: Discuss the bacteriostatic effect of wood dyeing

（1） Test material preparation:

A. The materials of the experimental group and the control group were cut into 100mm × 20mm × 5mm sizes.

B. Sterilization: sterilize with autoclave.

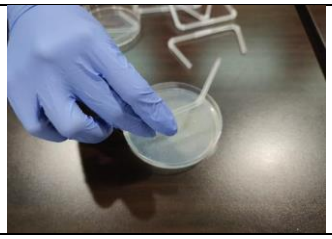
（2） Start experiment:

A. Culture: put the test material into potato agar (PDA) plastic culture medium after drying, in which the test material sheet and PDA must be separated by U-shaped rod.

B. Fabrication of U-shaped support frame: take 6mm bendable straw, cut the head and tail, and reserve 6 cm bendable straw for standby.

C. Preparation of fungal spore solution: dip a sterile cotton stick in sterile water to scrape the mycelia or spores on the fungal surface, and then place the cotton stick in a spray bottle filled with sterile water and stir it dozens of times as the spore suspension.

D. Antifungal test: Place the culture medium loaded with wood in a sterile environment (light the alcohol lamp), spray the water solution containing mold pods on the surface of the wood sample with a spray bottle, fix the number of presses on each plate, seal it with a sealing film, and place it in a growth box at 28 ℃. After 4 weeks, take it out and evaluate the anti-fungal effect.

		
Install U-shaped tube	Spray fungus liquid into spray bottle	Spray on wood

E. After the materials are taken out of the growth box and culture medium, the growth area of mold shall be evaluated by visual evaluation, and the rating shall be divided into three levels:

a. Lv.0 refers to the inoculation part of the test sample or test piece, and no mycelium development can be observed.

b. Lv.1 means that the area of the hyphae developed is not more

than 1/3 of the total area of the test piece.

c. Lv.2 refers to the area of the hyphal development part that exceeds 1/3 of the total area of the test piece.

9、 Experiment 5: To explore the anti-termite effect of herbal extract

（1） Preparation:

A. Put 2 soldiers and 18 workers in each petri dish in a ratio of 1 to 9 workers. Repeat the experiment in 7 groups (including the control group) and 3 groups. There are 42 soldiers and 378 workers in 21 groups.

B. Sterilize the culture dish and filter paper with UV-C light for 30 minutes.

（2） Start experiment:

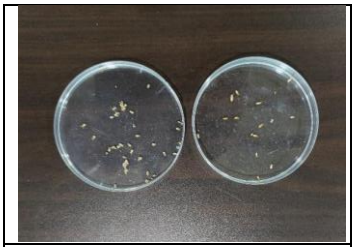
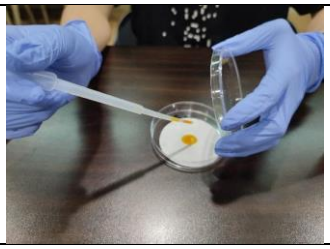
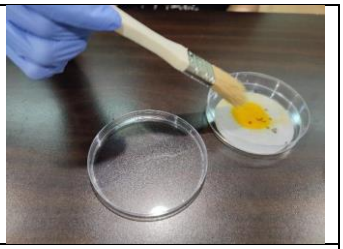
A. Take the extract solution, place a 7.0cm diameter round filter paper in a Petri dish (9cm in diameter and 1.5cm in height), drop 1.0ml of the extract solution, and make it completely wet on the whole round filter paper.

B. Place it for about 30min to volatilize the liquid, add the appropriate amount of distilled water to moisten it, then put 2 soldiers and 18 workers, and cover the petri dish.

C. Place them in a growth chamber with a temperature of 25 ℃ and 90% RH, and observe and record the number of deaths within 7 days. All treatments were repeated in 3 groups, and the non-treated group was used as the control group.

D. Results in the mortality rate and filter paper weight loss rate were calculated according to the following formula:

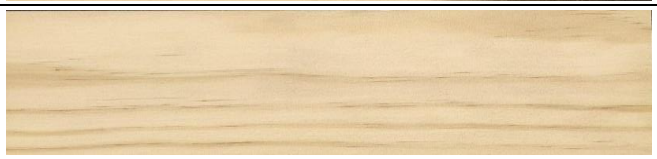
Termite mortality rate (%)=(number of dead termites/total number of termite tests) × 100%

		
worker ants (left) and soldier ants (right)	add the extract of medicinal materials	Put in termites to start the experiment

Ⅲ. Research Results & Discussion

1、 Experiment 1: Wood pretreatment

Take photos of bleached wood, measure the Lab values of five different points (upper, lower, left, right) with Photoshop, and then calculate the average value.

No.	Photo	Five point average CIE(L,a,b)
1		81 , 4 , 25
2		85 , 2 , 20
3		88 , 4 , 20
4		83 , 5 , 23
5		84 , 4 , 24
Control group unbleached		83 , 8 , 26

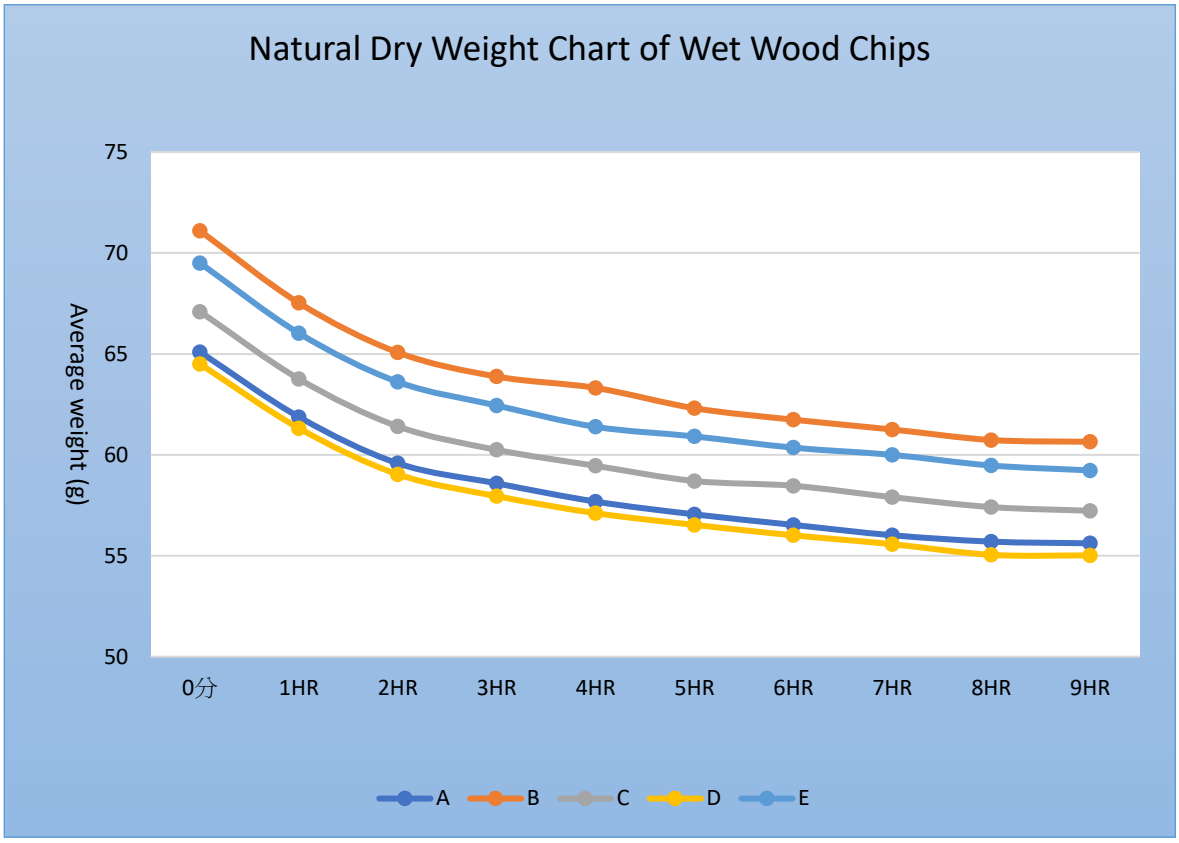
Results:

（1） the values of a and b in the control group were high and positive, showing that the unbleached color was red and yellow.。

（2） After bleaching, the values of a and b are low, close to the central value, and the visual color is relatively light.

2、 Experiment 2: Moisture absorption of wood and changes after drying

After fully wetting, place the wood in the indoor air conditioner at 26.5 ℃, and dry it naturally at 55% humidity. Record it once an hour.

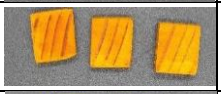
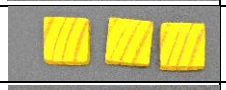


Results: In the early stage of drying, more moisture was lost, and the weight of wood chips was reduced. After 8 hours, it became less and less.

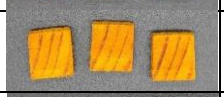
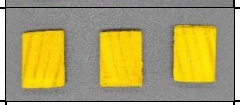
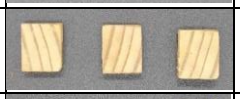
3、 Experiment 3: Discuss the dyeing fastness of wood after dyeing

（1） Influence of Acid and Alkali Aqueous Solutions and Interfacial Activators

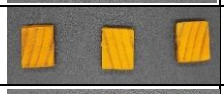
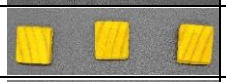
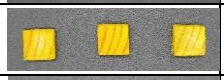
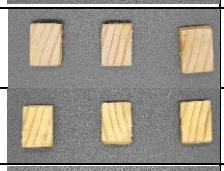
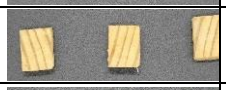
A. pH3 hydrochloric acid aqueous solution

Medicinal herbs	Before soaking	(L,a,b) mean value	After soaking	(L,a,b) mean value	Color difference
Lithospermum		(79.8 , 9.7 , 27.9)		(82.7 , 9.7 , 29.6)	3.4
Gardenia		(75.3,19.1,77.1)		(74.1 ,17.0 ,77.7)	2.5
Turmeric		(89.4 ,2.2,88.7)		(90.7 ,1.2 , 84.8)	4.2
Wolfberry		(82.5 ,3.6 ,25.5)		(83.2 ,2.8 ,22.3)	3.4
Tuber fleece flower		(90.6 ,2.7 ,37.5)		(87.8 ,3.7 ,38.5)	3.2
Rehmannia glutinosa		(84.4 ,7.8 ,34.5)		(88.3 ,7.3 ,35.6)	4.1
Results: After soaking in pH 3 hydrochloric acid solution for 15 minutes measure the color difference value: turmeric > rehmannia > lithospermum = wolfberry > uber fleece flower > gardenia					

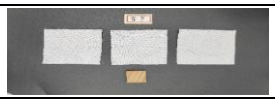
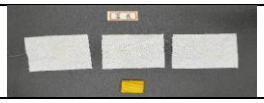
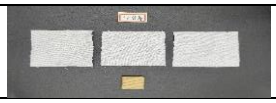
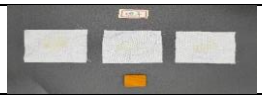
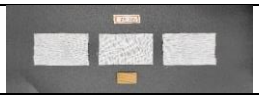
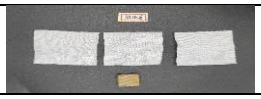
B. pH10 sodium hydroxide aqueous solution

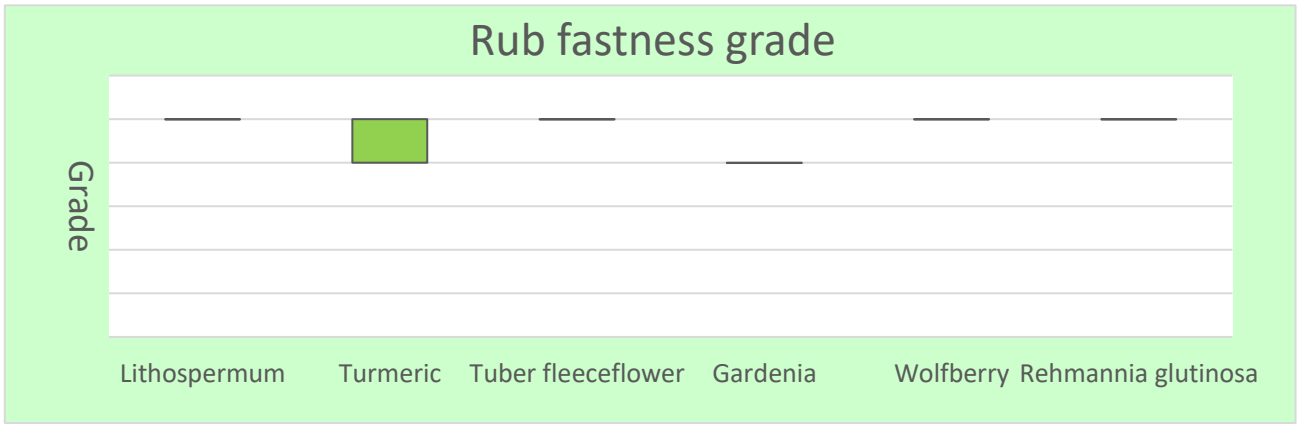
Medicinal herbs	Before soaking	(L,a,b) mean value	After soaking	(L,a,b) mean value	Color difference
Lithospermum		(82.8 ,9.8 ,29.4)		(81.4 ,8.5 ,28.6)	2.3
Gardenia		(74.2 ,19.2 ,79.1)		(72.9 ,20.2 ,77.7)	2.1
Turmeric		(89.2 ,0.6 ,85.6)		(89.7,0.9 ,83.2)	2.5
Wolfberry		(80.0 ,3.5 ,23.2)		(83.3 ,3.4 ,24.7)	3.6
Tuber fleece flower		(89.4 ,2.4 ,37.1)		(88.3 ,3.7 ,38.0)	2.0
Rehmannia		(84.3 ,7.9 ,36.0)		(88.5 ,6.7 35.6)	4.3
Results: After soaking in pH 3 hydrochloric acid solution for 15 minutes measure the color difference value: turmeric > rehmannia > lithospermum= wolfberry > tuber Fleece flower>gardenia					

C. Aliphatic alcohol surfactant aqueous solution

Medicinal herbs	Before soaking	(L,a,b) mean value	After soaking	(L,a,b) mean value	Color difference
Lithospermum		(82.0 ,9.2 ,28.8)		(81.1 ,8.5 ,28.8)	0.9
Gardenia		(75.4 ,19.7 ,77.6)		(74.4 ,18.7 ,77.4)	1.5
Turmeric		(87.5 ,-0.6 ,84.6)		(87.9 ,1.0 ,83.7)	1.9
Wolfberry		(84.0 ,2.9 ,23.4)		(85.0 ,2.1 ,24.4)	1.6
Tuber fleece flower		(90.4 ,2.0 ,37.0)		(89.5 ,2.5 ,38.4)	1.7
Rehmannia glutinosa		(86.5 ,7.2 ,34.9)		(87.2 ,8.0 ,35.5)	1.9
Results: After soaking in neutral fatty alcohol surfactant aqueous solution for 15 minutes, measure the color difference value: rehmannia=Turmeric > tuber fleece flower > wolfberry > gardenia > lithospermum					

(2) Testing of rubbing fastness:

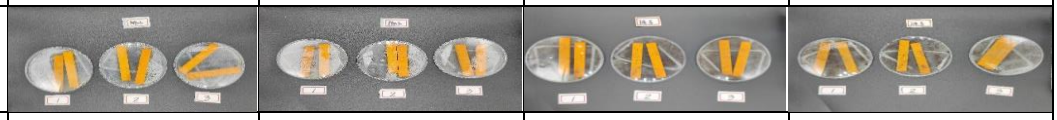
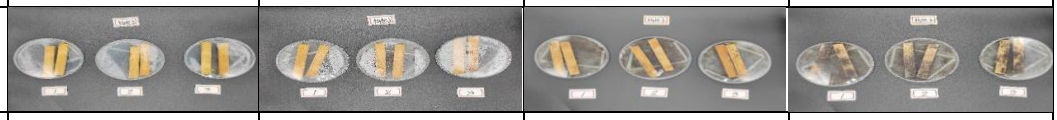
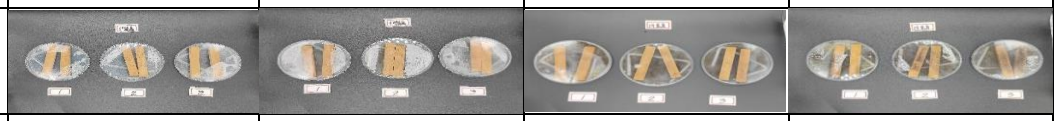
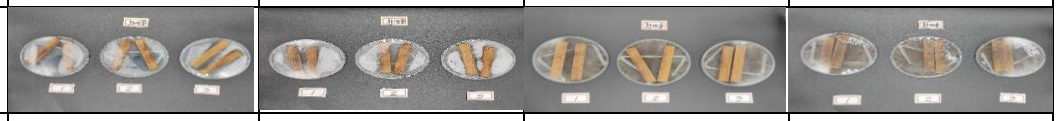
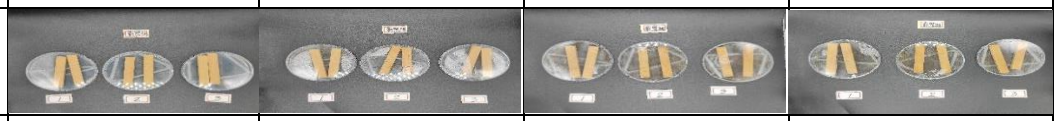
Medicinal herbs	Lithospermum	Turmeric	Tuber Fleece flower
Photo			
Grade	5	4-5	5
Medicinal herbs	Gardenia	Wolfberry	Rehmannia glutinosa
Photo			
Grade	4	5	5



Results After the friction test, judged from the contamination on the cloth, and the rubbing fastness was ranked from the best to the worst:

lithospermum = tuber fleece flower = wolfberry = rehmannia > turmeric > gardenia.

4、 Experiment 4: Discuss the bacteriostatic effect of wood dyeing

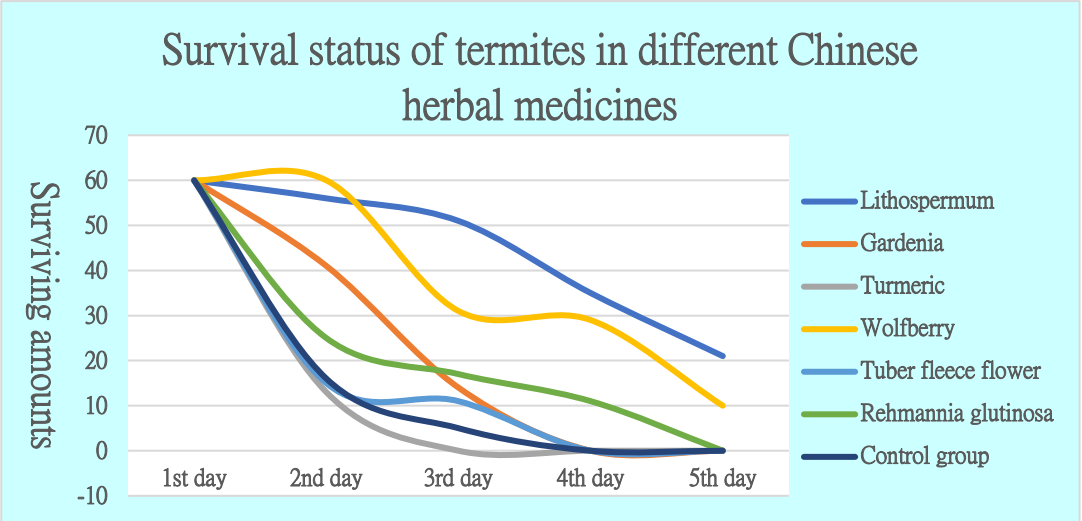
Medicinal herbs	3rd day	7th day	12th day	18th day
Lithospermum				
Bacteria	Lv0	Lv0	Lv1	Lv1
Gardenia				
Bacteria	Lv0	Lv0	Lv1	Lv1
Turmeric				
Bacteria	Lv0	Lv0	Lv0	Lv1
Wolfberry				
Bacteria	Lv0	Lv0	Lv1	**Lv2**
Tuber Fleeceflower				
Bacteria	Lv0	Lv0	Lv1	Lv2
Rehmannia glutinosa				
Bacteria	Lv0	Lv0	Lv1	Lv2
Control group (boric acid)				
Bacteria	Lv0	Lv0	Lv0	Lv0

Results

- 7th day, bacteria appeared：Rehmannia glutinosa.
- 12th day： There are bacteria growing in Rehmannia glutinosa, Lithospermum, Gardenia, Wolfberry, and Tuber fleece flowers.
- 18th day： Except for the control group treated with 2.0% boric acid, which was no bacteria growth, and others grew.

5、 Experiment 5: To explore the anti termite effect of herbal extract

Medicinal herbs	Lithospermum	Gardenia	Turmeric	Wolfberry	Tuber fleece flower	Rehmannia glutinosa	Control group
Photo							
1st day	60	60	60	60	60	60	60
2nd day	56	41	13	60	15	25	16
3rd day	51	14	0	31	11	17	5
4th day	35	0	0	29	0	11	0
5th day	21	0	0	10	0	0	0
Mortality	65%	100%	100%	83.3%	100%	100&	100%



Results

1. in the termite test, turmeric and boric acid in the control group were killed the fastest.

2. Tuber fleece flower, Gardenia, Rehmannia, Wolfberry, and Lithospermum in turn.

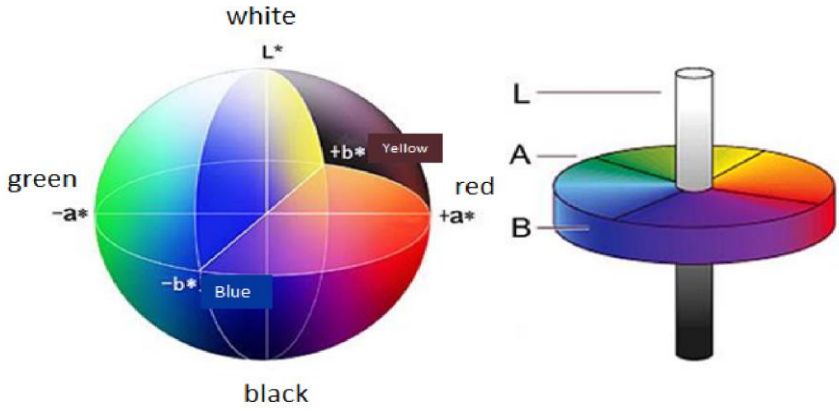
3. On the fifth day, only two groups survived: 21 Lithospermum (35%) and 10 wolfberries (16.7%).

6、 Experiment 1: Wood pretreatment

The effect of wood pretreatment affects the quality of the post-project. The pretreatment methods include physical and chemical methods. The physical methods include microwave pretreatment, supercritical fluid pretreatment, and steam explosion pretreatment. The chemical methods include alcohol, hot water, acid, and

alkali. Traditionally, NaOH is used to dissolve impurities such as pigments and tannins attached to wood. Our experiment adopts a chemical method and does not add NaOH, mainly because NaOH causes great damage to lignocellulose after dissolution. The amount of NaOH used is different due to the soft and hard density of the wood. In addition, this group uses white pine wood, which has a lower density and is cheap wood, and the indoor measured density is 0.4~0.5%. If NaOH is used, the wood strength will be reduced. Considering the cost, we don't use of alcohol method, and the hot water method requires high-pressure treatment, so the textile pretreatment method is used, only hydrogen peroxide and interfacial active agent are used for treatment. Hydrogen peroxide is harmless to cellulose, and the dyeing will be even after bleaching. In addition, there is no environmental problem in the treatment of NaOH wastewater.

The CIE Lab value measured after processing is determined by CIE (International Color Association) according to Munsell Color System, and the color space is represented by a sphere (as shown in the following figure):



From network: https://firstsun.pixnet.net/blog/post/40938127-what-is-rgb-hex-cielab

L：The shade of the color.

a：The degree of green or red:

- a indicates that the color is green, +a indicates that the color is red.

b：The degree of blue or yellow:

- b indicates that the color is blue, +b indicates that the color is yellow.

The color difference value is calculated by the distance between two points on the sphere: $C_1 = (L_1, A_1, B_1)$, $C_2 = (L_2, A_2, B_2)$

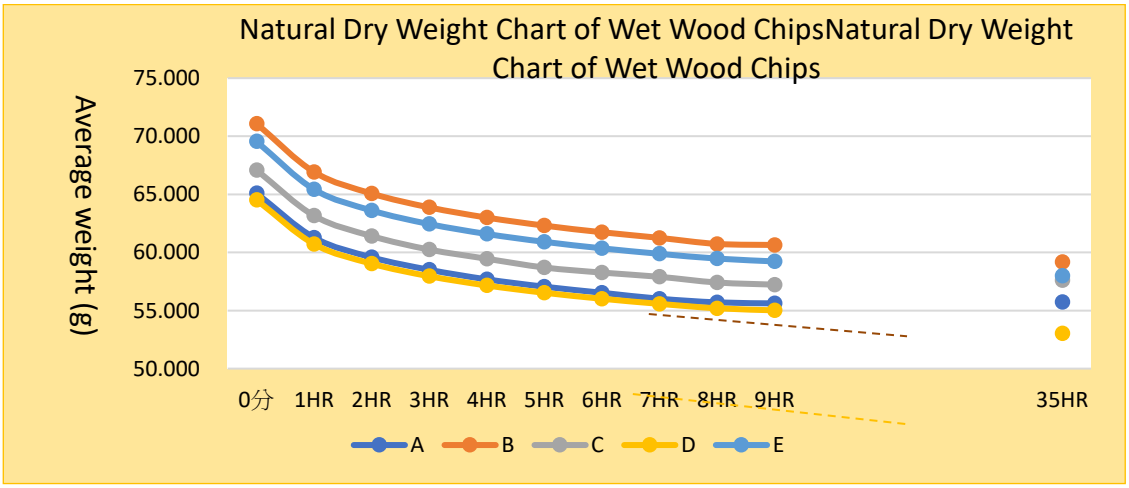
$$\text{Difference} = [\,(L_2 - L_1)^2 + (A_2 - A_1)^2 + (B_2 - B_1)^2\,]^{1/2}$$

7、 Experiment 2: Moisture absorption of wood and changes after drying

The degree of dryness of wood depends on its density. The higher the density is, the less moisture absorption will be. The lower the density is, the easier the moisture absorption will be. The density varies with species, growth environment, and organizational structure; For wood with high moisture content, it is not easy for dyes to enter the wood for dyeing, but excessive moisture will cause uneven dyeing of the dyed wood. It is better to choose wood with appropriate moisture content for dyeing. For wood with high density, it is difficult to dye by adding pressure or penetrant.

Water content is very important to wood, the first of which is transportation cost. Wood transportation is not calculated by volume, but by weight. The water content affects the color quality of the paint. Often in the newly constructed flat board, the board will bulge due to the water leakage of the house, which is due to the dimensional stability of the wood. The water content of the wood for indoor construction should be lower than that for outdoor use. In addition, the cross-section of wood when cutting is much more hygroscopic than other surfaces, so primer treatment should be done, because the moisture entering the wood easily corrodes the wood. And also related to the growth of the growth ring affected by seasons. In winter, the growth color is dark and hard, and it is difficult to absorb water, while in spring and summer, the growth is easy to absorb water and is soft.

In our drying experiment, the group was to dry the test material at 50 ℃ for 26 hours after the completion of natural drying, so that the test material would not be damaged, and the weight taken out will no longer be reduced. This is not an absolute dry weight. The absolute dry condition is 100~105 ℃, and the dry until the quality remains unchanged. See the figure below.

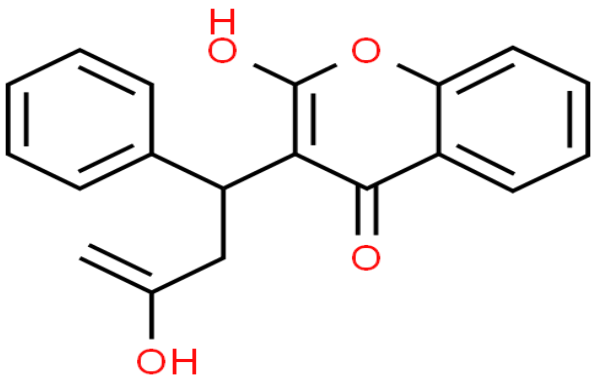


8、 Experiment 3: Discuss the dyeing fastness of wood after dyeing

Wood dyeing has become fashionable in recent years because it can improve its added value. However, the development of dyes is not as rich as that of textiles. This group referred to Peng Zhengzhong (1976) Dyes and Dyes, a book printed by Zhonghua Book Company, and arranged the dyes:

As the name implies, direct dyes can be dyed by heating in neutral and weaker ions without dye aids. Their combination with lignocellulose depends on intermolecular van der Waals and hydrogen bonds; It can be seen here that acid dyes are used to dye wood. Because acid group H+ are contained in the dye molecules, it can actually be combined with amino groups in protein fiber molecules by ionic bonds. For example, wool animal fibers, because acid dyes contain a large number of carboxyl, hydroxyl, or sulfonic groups, can be combined with OH+on wood cellulose. Reactive dye: the dye molecule contains reactive dyes that can react with hydroxyl groups in cellulose and amino groups (NH4+1) in protein fibers. Reactive dyes are bright in color. Dye solution at room temperature or slightly heated is sufficient. The molecule contains reactive groups and can form covalent bonds with hydroxyl groups in wood.

This experiment uses traditional Chinese medicine, which is taken from the plant itself. It contains polyphenols and carbohydrates, all of which have the same kind of substances, and are easy to combine with cellulose. The cellulose structure is as follows.



From https://sites.google.com/a/westcta.ccsd.net/ibuprofen-chemistry/microcrystalline

This group does not add metal dye aids, although it can improve the fastness and enrich the color, in terms of environmental protection and children's toys, residual metal dyes are not allowed. In this experiment, the dye solution is supersaturated.

Some of them will fade, such as turmeric (rhizome) and gardenia (fruit), which are bright in color, and the medicinal materials are not powdered, but there is a lot of fading. Although there is a second cleaning after dyeing, there will still be a "colored" aqueous solution. The two materials should be added with color-fixing substances: perhaps they can be dyed in acid (adding acetic acid) or added with salt (Na+C-l) electrolyte, Or turmeric dyed with alcohol can also be improved by dissolving curcumin. In this experiment, turmeric is yellow at pH<7.4, but not reddish brown at pH>8.6 under alkaline conditions. It is judged that curcumin is not dissolved; Rehmannia glutinosa is prepared by repeatedly steaming and drying its tubers after being fed. Rehmannia glutinosa can be used for fabric dyeing. After dyeing in this group, its dark color is like walnut, with potential development.

9、 Experiment 4: Discuss the bacteriostatic effect of wood dyeing

In this experiment, natural materials were used to inhibit fungi, and all fungi were found within three weeks as expected. Among them, turmeric has been maintained for a longer time, the natural substances contain polysaccharides, which instead become a nutrient for fungi. However, 2% of boric acid in the control group has no fungi, and the boric acid solution is colorless and tasteless, which can be used to supplement the bacteriostatic effect of natural plant medicines.

10、 Experiment 5: To explore the antitermite effect of herbal extract

In this experiment, the extract of traditional Chinese medicine was used to feed termites. After five days, with Lithospermum only 21 of the 60 termites survived, accounting for 35%, and 10 of the Wolfberry survived, accounting for 16.7%; Wolfberry is sweet in nature and contains sugars, which could be the reason why termites can survive; Also with some elders saying, only non-boiling extraction is effective when extracting Lithospermum, which can be proved by experiments.

IV. Conclusion and application

Conclusion

1、 Experiment 1: Wood pretreatment

Before wood dyeing, pretreatment must be carried out to remove pigments, tannins, and other impurities that affect the dyeing, so as to reduce external interference in the dyeing project. The wood selected in this group is relatively soft, so only 5.0% H2O2 is used for bleaching, and then 5.0g/l fatty alcohol surfactant is used for washing. Lab value measured after bleaching: the red and yellow parts are reduced, indicating that the bleaching effect is reached.

2、 Experiment 2: Moisture absorption of wood and changes after drying

After moisture absorption, the test material will be dried for about 8~9 hours under constant temperature and humidity in the indoor air conditioner. Continue drying at 50 ℃ for 35 hours to achieve a dry degree. After drying, the test material will be placed indoors. The quality will change due to changes in temperature and humidity.

3、 Experiment 3: Discuss the dyeing fastness of wood after dyeing

After being bleached, the test materials were dyed with six different Chinese medicinal materials, and the color after being dyed with "rehmannia" was similar to that of high-value walnut. After immersion in pH 3 hydrochloric acid and pH 10 sodium hydroxide aqueous solution for 15 minutes, the color difference value is between 3 and 4, indicating that strong acid or strong acid treatment is not allowed after dyeing with Chinese herbal medicine. In addition, if the detergent is soaked for 15 minutes, the color difference value is less than 2, which requires an experienced observer to notice the difference; The rubbing fastness is above grade 4.

4、 Experiment 4: Discuss the bacteriostatic effect of wood dyeing

During the bacteriostasis time, no fungus was found on the first three days of the six test materials. On the seventh day, it was found in Rehmannia glutinosa group, and on the twelfth day, no fungus was found in the control group in the 2.0% boric acid aqueous solution. This provided a method to inhibit fungi for this group of experiments, that is, boric acid can be added at the time the traditional Chinese

medicine staining.

5、 Experiment 5: To explore the anti termite effect of herbal extract

In this experiment, six kinds of Chinese medicinal materials' effects on termite resistance result good, and the fastest death is turmeric and boric acid in the control group; On the fifth day, only two groups survived: 21 lithospermum (35%) and 10 wolfberry (16.7%).。

Application

1. With the continuous development of natural forest resources, people have less and less precious wood. Wood dyeing can improve the decorative quality of wood. Wood dyeing can be used to make all kinds of wood with bright color, clear texture, and natural wood characteristics. It can be used to produce industrial products in line with market demand to improve the value of low-quality wood, reduce the cutting of precious trees, and also have the function of environmental protection and carbon reduction.

2. In this experiment, it is initially feasible to dye the cheap radiata pine wood with the extract of traditional Chinese medicine. However, there are still many post-processing works to be treated, just like fabric dyeing, finishing treatment is still required; After treatment of wood, it is a long way. At present, the problems to be overcome list as in below:

   （1） Natural medicinal materials have bacteriostatic effect. In order to avoid "polysaccharides" in plant materials and let bacteria grow nutritionally, it is proposed to use borax (called lunar stone in Chinese medicine) with natural minerals to prevent and control biological hazards.

   （2） The increase of wood strength, that is, the increase of density, is intended to be filled and improved in the low density wood gap with cohesive and significant materials (such as silver ions, which also have bacteriostatic effects).

   （3） Beeswax or paraffin oil can be used to increase the brightness and waterproof protection of the dyed wood.

V. References

1. Luxia Chen, Dongming Guan , Da Wang, Huijuan Zhang(2014) **Progress of Lignocellulose Pretreatment Technologies** Bioprocess Vol.4 No.03(2014), Article ID:14038,9 pages DOI:10.12677/BP.2014.43004
2. Rubin Shmulsky, P. David Jones(2011) **Forest Products and Wood Science An Introduction**
3. Wang Songyong (2018) Wood Physics (Updated Edition): Physical Properties. Taipei. New Xuelin Publishing
4. Chen Dianli, Hong Peifen (2010) Research on Visual Image of Wood Material Dyeing and Painting Department of Industrial Design, National Taipei University of Science and Technology
5. Zhang Manjian (2008) Research on the ancient books of Chinese herbal cosmetics and the application of Lithospermum in cosmetics, Ph.D. thesis of China Institute of Pharmacy, China Medical University.
6. Guagua Insect Net termite 20220826 from http://gaga.biodiv.tw/9708bx/092.htm
7. Peng Zhengzhong (1976) Dyes and Dyeing, Printed by Zhonghua Book Company
8. Wang Songyong (2006) The effect of antiseptic and insect resistant treatment on the physical and mechanical properties of large wood structures, Ministry of Interior, Architectural Research Institute.
9. National Standard of the Republic of China CNS 14730 Determination of Preservative Absorption of Preservative Treated Wood. Bureau of Standards and Inspection, Ministry of Economy.
10. National Standard of the Republic of China CNS 15756 (2014) Test Method for Wood Termite Resistance. Bureau of Standards and Inspection, Ministry of Economy.
11. Lai Xiujing (2005) Wood dyeing of tea extract Master thesis of Department of Wood Industry, Pingtung University of Science and Technology
12. Wu Baide (2012) Academic Paper on the Elimination of Active Oxides and Nitrogen Compounds by Sixteen Medicinal Plants
13. Zhang Jiahao (2011) Evaluation of Cornus officinalis extract for termite resistance
14. Liu Wentang et al. (2012) Discussion on the anti termite activity of medicinal plants against ethanol and water extracts of Rhizoma stemonae; Volume 10, Issue 2, P39 – 53

15. Li Weizhen (2013) Permeability of commonly used wood preservatives in Taiwan and moldy phenomenon of treated wood
16. Ma Fenmei (1992) Research on the traditional plant dyeing of areca and dioscorea
17. Zeng Yunhan (2014) Research on the dyeing change of natural fibers dyed by natural dyes on Master thesis of Tainan University of Applied Science and Technology, Tainan

【評語】100008

1. 本作品由生活議題出發，正視生活品質問題，值得肯定。

2. 本作品的實驗設計、數據收集、結果分析等說明清楚。

3. 不同酸鹼溶劑浸泡對於色差之影響可進一步分析。

4. 經觀察薑黃與硼酸有好的抑菌效果，建議可分析背後物理化學機制。