Radiation Research (2018)

ORIGINAL RESEARCH ARTICLE

Anti - UV Finishing of Cotton Fabrics with Lithospermum Extract

Shengbo Liu,Lingxia Zhao,Dongxu Wu

School of Materials Science and Engineering, Suining University of Technology, Sichuan, China

ABSTRACT

Lithospermum extract from Lithospermum is a kind of naphthoquinone, which has good anti-ultraviolet and anti-bacterial function. In this paper, the effects of different treatment temperature, time and ratio of liquid to liquid on the UV resistance of Lithospermum erythrorhizon extract were studied. The optimum extraction conditions were as follows: extraction temperature 60 ℃, extraction time 2 h, ratio of liquid to liquid of Lithospermum and ethanol 1:11. In this paper, the anti-UV finishing of cotton fabric was carried out, and the anti-ultraviolet and whiteness of the fabric were taken as the main indexes. The optimum process of the anti-UV finishing was as follows: the impregnation temperature was 70 ℃, the immersion time was 2h, 1:40. Compared with the uncoated cotton fabric, the fabric UPF value of the fabric was improved from 12.31 to 83.25, and the anti-ultraviolet performance was excellent, and it had certain bacteriostatic effect on Bacillus subtilis and Escherichia coli.

KEYWORDS: Cotton fabric; Lithospermum; extract; Anti-ultraviolet performance; Whiteness

1. Introduction

The rapid development of industry, air pollution is more and more serious. Since the thickness of the stratospheric ozone layer observed in Antarctica in October 1982 has been rapidly reduced and the ozone layer has existed, the problem of ultraviolet radiation has become one of the focuses of the ozone layer. UV is the wavelength of 180-400nm range of radiation, according to the wavelength of UV - A (320-400nm), UV - B (280-320nm) and UV - C (200-280nm) three. UVA, is the wavelength of 320-400nm ultraviolet. Long wave of ultraviolet light on the human body and clothing penetration than the wave of ultraviolet light is much stronger, can reach the depths of the dermis, and can play a role in the skin melanin, resulting in melanin skin, so that the skin black, played a defense against ultraviolet light, and protect the skin. So the long-wave ultraviolet light called ‘tanning’. Although long-wave UV has no effect on acute inflammation of the skin, it can act on the skin, so it is one of the causes of skin aging and serious damage. UV-B is 1000 times the effect of UV-A, the summer enzyme is mainly due to the role of UV-B, subcutaneous blood vessels absorb ultraviolet B will cause expansion, resulting in the skin becomes red to produce erythema, serious may occur Inflammation. UVB can also affect the subcutaneous elastic fibers, will lead to loss of elasticity of the skin, so that the skin to form a more rough wrinkles, UVC as a stronger ultraviolet, have a certain bactericidal effect, but also harmful to humans. In general, UV C cannot penetrate the atmosphere to reach the ground. In order to reduce the harm of ultraviolet light to human beings, people need to develop a variety of anti-ultraviolet penetration of textiles, the development of a clear anti-ultraviolet radiation function of new textile products with urgent market demand and important practical significance. Cotton fabric and blended fabric, has a good hygroscopicity and softness, is the popular summer fabric, but the anti-ultraviolet properties of cotton fabric in natural fibers and chemical fiber in the poor, the UV-A and UV -B band of ultraviolet light have a higher transmittance [1-7]. So the cotton fabric needs anti-ultraviolet function of the finishing, in order improving its added value.

Ultraviolet radiation has an impact to the fabric, part of the absorption, part of the reflection, part of the transmission, through the ultraviolet radiation on the skin. In general, the transmittance + reflectance + absorbance = 100%. There are two main mechanisms of action of ultraviolet textiles: absorption and reflection, the corresponding UV shielding agent with two kinds of absorbers and reflectors. The absorbent and the reflector may be used alone or in combination. UV reflector mainly uses the scattering and reflection of inorganic particles, can play anti-UV transmission effect. UV absorbers mainly use organic substances to absorb ultraviolet light, in order to carry out energy conversion, in the form of harmless low radiation or heat energy release or consumption. Organic UV absorbers can absorb ultraviolet rays in the wavelength range of 280 to 400 nm, so that they change from ground state to excited state and convert energy to low

energy or wavelength electromagnetic waves to eliminate the harmful effects of ultraviolet rays on the human body and fabric. [8-9]

Natural material Lithospermum is the main component of Shikonin, containing two phenolic hydroxyl groups of a-naphthoquinone and its glycosides, Lithospermum of this special structure, as an organic UV absorber adsorbed on the fabric surface to make it Has a good UV absorption function. [10] In addition, Lithospermum has antibacterial, antiviral effect, Lithospermum extract Shikonin, Penta-pentenoic acid and other components, *in vitro* on Staphylococcus aureus, Bacillus subtilis, Escherichia coli and so have the inhibitory effect after the ethanol extraction of the organic UV absorber, the cotton fiber was finished by impregnation method, which gave it good anti-ultraviolet property. In this paper, the extraction technology of Lithospermum erythrorhizon and the finishing process of cotton fabric [11-13] were discussed.

2. Experimental materials and methods

2.1. Experimental materials and reagents

2.1.1 Materials

White cotton fabric (surface density of 140g / ㎡)

2.1.2 Test Drugs

95% ethanol Lithospermum (pharmacy purchase)

2.1.3 Test equipment and equipment

YP202N electronic balance (Shanghai Precision Instrument Science Co., Ltd.);

HH-S constant temperature water bath (Jiangsu Guosheng test equipment factory);

101-5 type electric blower (Shanghai County test instrument Ⅲ factory);

SBDY-1 digital brightness meter (Shanghai Yue Feng Instrument Co., Ltd.);

YG (B) 026D-250-type electronic fabric strength instrument (Wenzhou Da-rong Textile Standard Instrument Factory);

YG (B) 912E-type anti-UV properties of textiles tester (Wenzhou Da-rong Textile Instrument Co., Ltd.)

Beaker, Measuring cylinder, Funnel, Filter paper, Glass rods and so on.

2.2. Test methods

2.2.1 Preparation before trial

The cotton fabric cut into 8cm wide 8cm latitude and longitude to the sample, tear off the side yarn, drying, measuring the weight. The main factors affecting the anti-UV performance of cotton fabric are the main factors: the extraction temperature of Lithospermum Erythrorhizon, the extraction time of Lithospermum Erythrorhizon, the ratio of material to liquid, the impregnation temperature of cotton fabric, the time of impregnation of cotton fabric and the ratio of cotton fabric impregnation. The test is divided into six groups, each group to do a single factor change, in addition to cotton fabric dipping bath than to take three parallel, the other five factors take five levels.

2.2.2 Process

2.2.2.1 Lithospermum extract extraction process

Shredded with shredded shredder, accurately weighed a certain amount of Lithospermum 95% ethanol soak for a certain time, extraction, extraction and extraction of Lithospermum extract;

2.2.2.2 Cotton fabric finishing process

The cotton fabric impregnated into the extract of Lithospermum, at a certain temperature, a certain bath than the next impregnation for a certain time, after washing, at 60 ℃ under the conditions of drying.

2.3. Performance determination

2.3.1 Determination of anti-ultraviolet properties

Evaluation of anti-ultraviolet performance indicators are generally: UV transmittance and UV protection factor. UVR transmittance: The ratio of the UV transmittance flux when there is a sample to the UV transmittance flux when there is no sample is often divided into UVA and UVB transmittance UVR masking rate (or shielding rate). The formula is: = 1 - transmittance.

UV protection factor UPF (Ultraviolet Protection Factor): UPF is not used when the protective effect of the UV radiation effect and the use of protective materials calculated when the ratio of ultraviolet radiation effect.

The UV protection factor (UPF) of the fabric was measured on a YG (B) 912E type anti-ultraviolet test instrument. The specimens were cut into 8cm length 8cm latitude and longitude spline and the UPF index was used to evaluate the UV resistance of the fabric.

2.3.2 Determination of whiteness

Whiteness is also called brightness and material on the light from the reflection of reflection, the role of the human eye produced by the impression. It Indicates the degree of luminosity of the substance. The whiteness of the test substance is usually 100% of the standard whiteness of magnesium oxide and is set to 100% of the standard reflectance, and the whiteness of the sample is expressed as a percentage of the reflectance of the surface of the standard plate of magnesia irradiated with blue light. The higher the reflectivity, the higher the whiteness, Using ZBD-type white instrument. Will be collated before and after the sample folded, the measurement error of ± 2 degrees, take 5 times the average. See the brightness meter display readings.

2.3.3 Determination of breaking strength

This test is used to pull the edge of the sample method, because the edge of the experimental results is relatively stable. The effective working width of the sample is 5cm and the clamping length is 30cm. In the test, pre-tension must be applied to the specimen before clamping the clamp to eliminate the slack of the fabric and obtain the correct elongation. At the same time to ensure that the sample is flat and vertical clamping, so that the vertical yarn perpendicular to the clamp jaw line, to ensure the strength of accurate. Using YG065H electronic fabric strength machine, and according to GB GB / T3923-1995, by the three times to take the average.

2.3.4 Determination of wrinkle recovery angle

The wrinkle resistance of the fabric can be expressed by the crease angle. The measurement method of the fracture angle of the experiment is determined according to the vertical method in GB / T 3819-1997: 'Determination of the recovery of the crease of textile fabric'. The fabric samples were cut in accordance with Fig. 1, three to three. The specimen was fixed on the board, the return wing folded along the crease line, the sample pressure load of 10N, to withstand the pressure time of 5min ± 5s.It measured by the vertical folding method, read the sample just after unloading the load 15s after the crease angle for the rapid response, read the unloading load 5min after the wrinkle recovery angle for the bullet. If the free end of the specimen is slightly curled or twisted, the average angle of the three measured values is taken from the center of the free end, and the average of the three zonal measurements is taken.

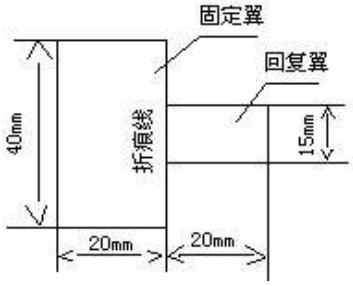

Figure 1. wrinkle recovery test sample

3. Results and discussion

3.1. Preparation of Lithospermum Extract

In this paper, the optimum extraction technology of Lithospermum Erythrorhizon was determined by using the anti -

3.1.1 Extraction of temperature effects

Table 1. Effect of extraction temperature of Lithospermum on fabric performance

Temperature(° C)	Whiteness（%）	Transmittance Average（%）		Anti-UV Performance Performance (UPF)
		UVA	UVB	
Original	79.7	10.14	7.33	12.31
30	27.5	3.44	2.33	41.09
40	25.1	2.92	1.83	50.76
50	21.2	2.1	1.05	76.94
60	20.3	1.87	1.03	83.25
70	22.1	2.1	1.29	72.63

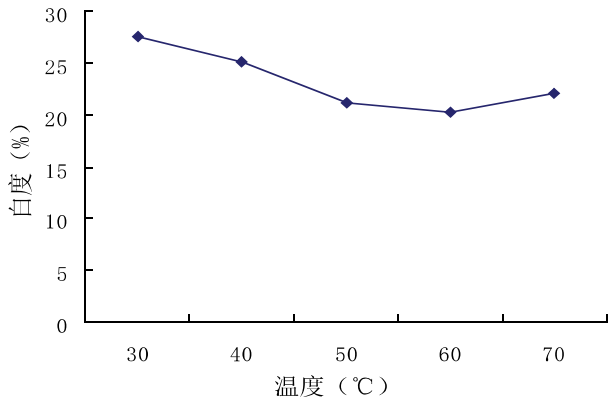

Figure 2. Relationship between whiteness of fabric and extraction temperature

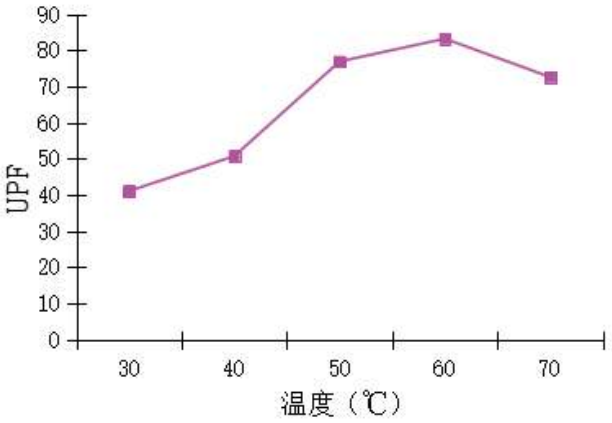

Figure 3. Relationship between extraction temperature and fabric resistance to UV resistance

It can be seen from Table 1 and Fig. 1 that the whiteness of cotton fabric decreases continuously with the extraction temperature of Lithospermum erythrorhizon, but after 60 ℃, the whiteness increases slightly with the extraction temperature rising. Lithospermum ethanol extract can be used as organic UV absorber, with the extraction temperature increases, cotton fabric surface adsorption of Lithospermum extract also increases, so the fabric whiteness is declining.

As can be seen from Table 1 and Figure 2, with the rising temperature of Lithospermum, the anti-UV properties of the fabric increased first and then decreased. With the increase of extraction temperature, the extract of Lithospermum erythrorhizon increased, and the UV absorption dose of the impregnated cotton fabric increased, and the UPF value of the fabric increased, and its anti - ultraviolet performance increased. However, when the extraction temperature reached 60 ℃, the fabric's UV resistance UPF decreased. This may be because the temperature is too high, resulting in the solution of Lithospermum extract molecular structure is unstable, decomposition, the anti-UV effect of the fabric decreased. Comprehensive consideration with Lithospermum as raw material, 95% ethanol for solvent extraction temperature should be selected 60 ℃.

3.1.2 Lithospermum / Ethanol ratio of material to liquid

Table 2. Effect of liquid ratio on performance of cotton fabrics.

Liquid	Whiteness (%)	Transmittance Ave (%)		Anti-UV Performance (UPF)
		UVA	UVB	
Original	79.7	10.14	7.33	12.31
1:7	33.1	3.48	2.38	36.19
1:9	31.7	3.64	2.44	39.33
1:11	28.4	3.84	2.11	40.76
1:13	35	4.2	2.79	32.69
1:15	37.1	4.47	3.08	31.41

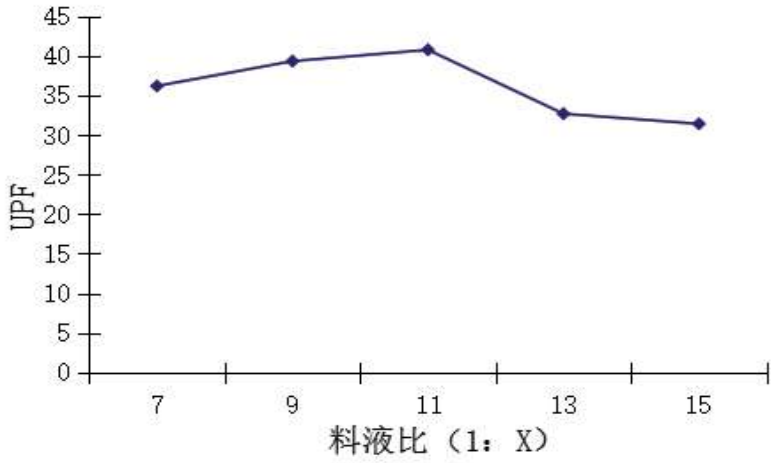

Figure 4. fabric anti-UV performance and material ratio changes.

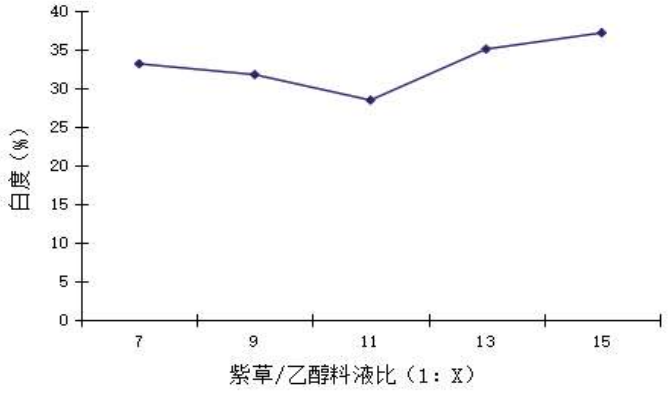

Figure 5. fabric whiteness and material to liquid ratio changes.

It can be seen from Table 2, Fig. 3 and Fig. 4 that with the increase of the ratio of liquid to liquid of Lithospermum and Ethanol, the whiteness of the fabric does not change much, and the anti-ultraviolet performance of the fabric increases first and then decreases. This is because, when the amount of ethanol is less, Lithospermum cannot be completely dissolved, the amount of extraction is small; with the increase in the amount of ethanol, making Lithospermum dissolved completely, the amount of extraction also increased, finishing fabric anti-UV performance Increase and whiteness continues to decrease. However, when the liquid is relatively large (1:11 or more), the concentration of dissolved Lithospermum decreased continuously, and the concentration of the extract was decreased. The anti-ultraviolet property of the fabric was also reduced and the whiteness was improved. Taking into account the extraction conditions should be selected material ratio of 11ml95% ethanol / 1g Lithospermum.

3.1.3 Effects of extraction time

Table 3. Effect of extraction time on cotton fabric properties.

Extraction Time （h）	Whiteness （%）	Transmittance Ave （%）		Anti-UV Performance （UPF）
		UVA	UVB	
Original	79.7	10.14	7.33	12.31
1	27.2	2.9	2.09	45.72
2	25.9	2.99	2.02	48.04
3	30.3	3.04	2.08	43.42
4	31.4	3.48	2.28	41.99
5	32.3	4.1	2.82	40.92

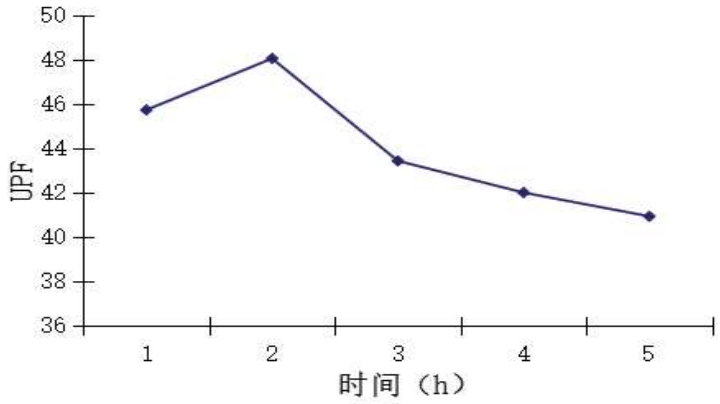

Figure 6. Relationship between anti-UV properties and extraction time of fabric.

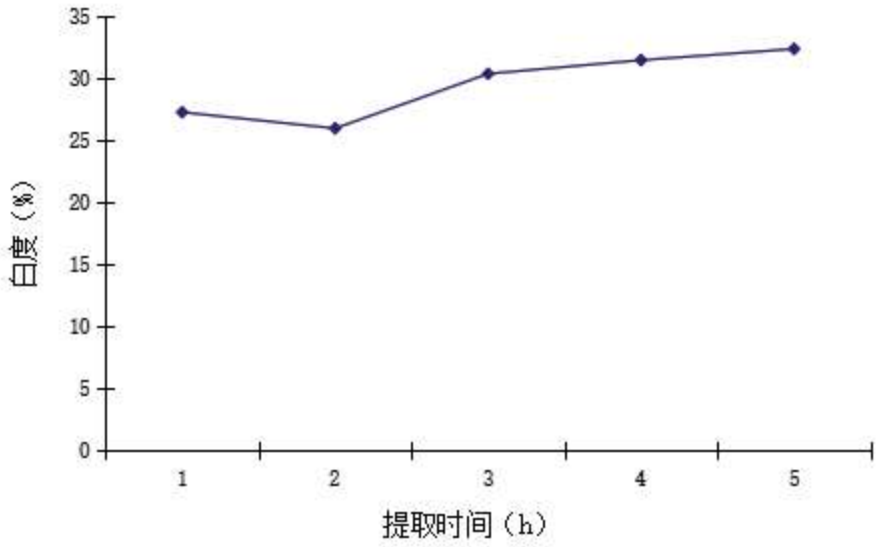

Figure 7. The relationship between the whiteness of the fabric and the extraction time

In the other conditions remain unchanged, the chart shows that within 2 hours before the extraction of Lithospermum, with the increase in extraction time, fabric whiteness decreased and anti-UV performance. The UPF value reaches the maximum after 2 hours of extraction. When the extraction time in 2 hours later, as time continues to extend, fabric whiteness gradually increased and anti-UV performance decreased slightly. This was due to the fact that the concentration of the extract did not reach saturation after 2 hours of extraction, and the extraction of the extract gradually increased with the increase of time. After that time, the molecular structure of the extract of Lithospermum erythrorhizon extract was unstable and decomposed The anti-UV effect of the fabric is reduced. So the extraction time is 2h is appropriate.

3.2. Cotton fabric anti-UV finishing process

The best finishing process of cotton fabric was determined by using the anti - ultraviolet property of the cotton fabric after finishing with the extract of Lithospermum.

3.2.1 Effects of immersion time

Table 4. Effect of immersion time on cotton fabric properties.

Immersion Time（h）	Whiteness （%）	Transmittance Ave （%）		Anti-UV Performance （UPF）
		UVA	UVB	
Original	79.7	10.14	7.33	12.31
1	25.9	3.21	2.38	42.51
2	21.8	3.14	2.2	44.83
3	25.6	3.5	2.24	40.62
4	23.0	3.54	2.39	40.2
5	24.1	3.42	2.3	40.14

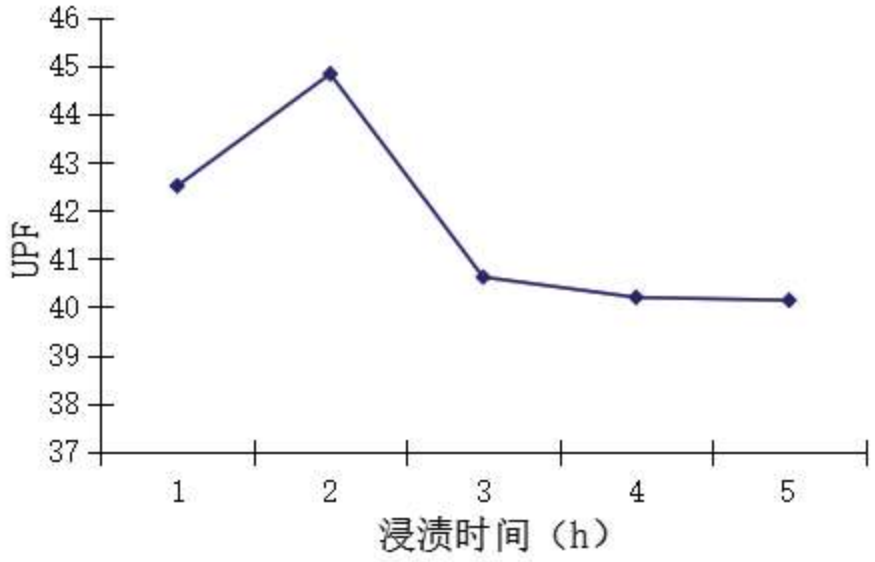

Figure 8. The relationship between the anti-UV properties of the fabric and the immersion time.

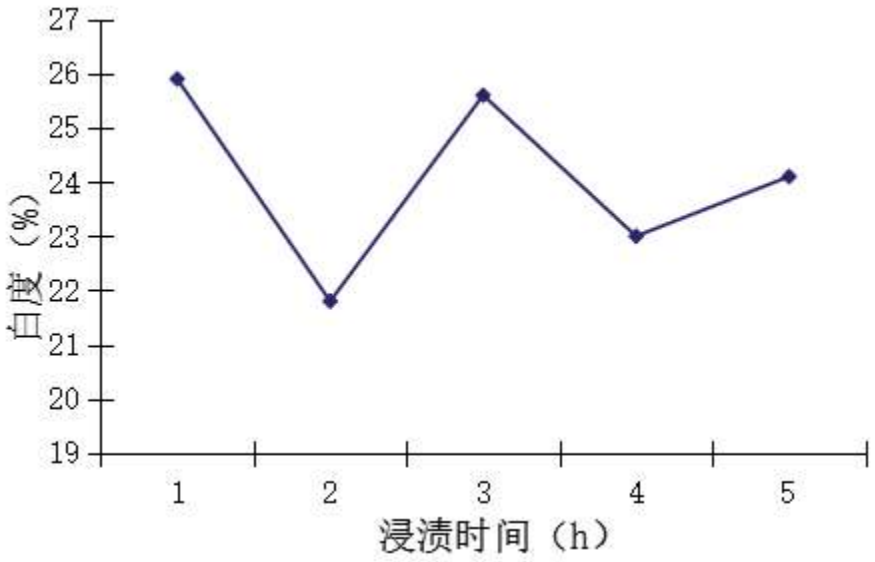

Figure 9. The relationship between the whiteness of the fabric and the immersion time.

It can be seen from the chart that the cotton fabric after a relatively short period of time after its anti-UV performance significantly improved, with the cotton fabric impregnation time gradually increased, cotton fabric anti-UV performance. When the immersion time is 2 hours, the anti-UV performance (UPF) of the cotton fabric is the best, and the immersion time is continued. The UPF value of the fabric is basically balanced. This is because the extraction of the surface of the cotton fabric with the increase in the immersion time is also increased, when the immersion time is 2 hours, the cotton fabric surface to absorb the extract to achieve saturation, cotton fabric at this time to achieve maximum UV resistance, continue The fabric is impregnated and tarnished, and the extract on the surface of the fabric remains basically unchanged. It is reflected that the UPF value is basically balanced on the cotton fabric. As the immersion time increases, the fabric whiteness fluctuates.

3.2.2 Effects of impregnation temperature

Table 5. Effect of dipping temperature on cotton fabric properties.

Impregnation Temp（℃）	Whiteness （%）	Transmittance Ave（%） UVA	UVB	Anti-UV Performance （UPF）
Original	79.7	10.14	7.33	12.31
30	28.4	3.84	2.41	38.49
40	27.2	3.52	1.84	43.75
60	26.9	2.79	1.74	52.67
70	22.7	2.56	1.52	58
90	25.1	2.35	1.75	53.1

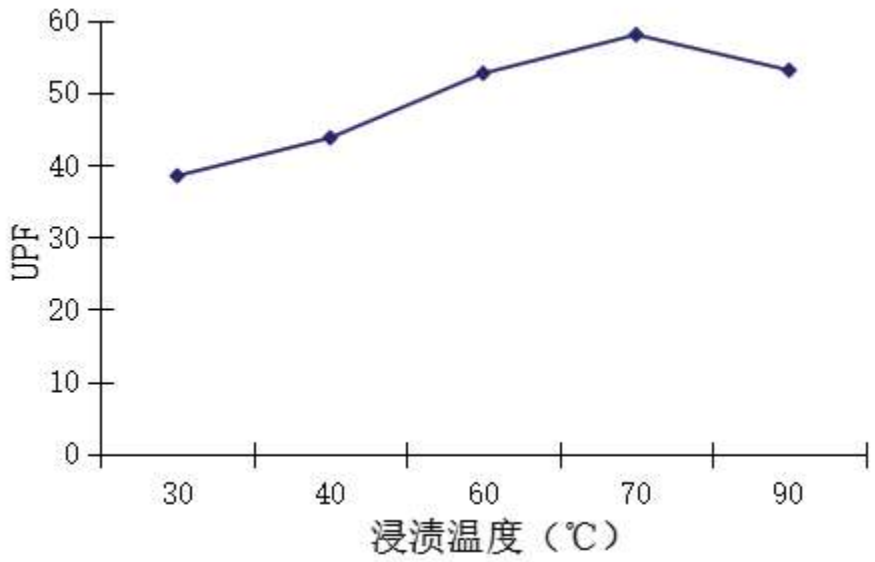

Figure 10. The relationship between the UV resistance of the fabric and the temperature of the impregnation.

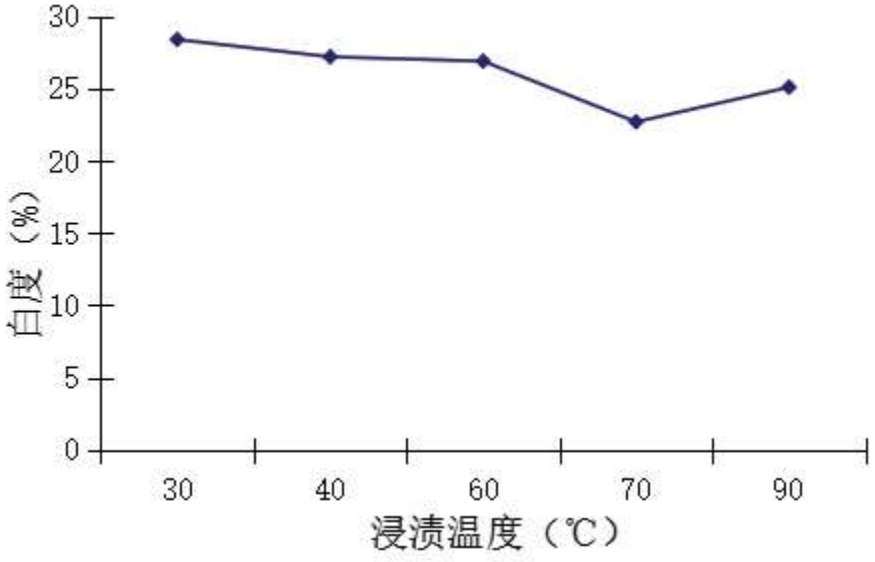

Figure 11. The relationship between the whiteness of the fabric and the impregnation temperature.

It can be seen from the chart that the whitening resistance of the cotton fabric increases with the increase of the cotton fabric impregnation temperature. However, the UPF value of the fabric decreases when the impregnation temperature is higher than 70 ℃. This is because the temperature rise at the beginning is favorable for the adsorption of the extract on the surface of the cotton fabric to improve the UV resistance. When the temperature is too high, the concentration of the chemical reaction solution in the extract will be reduced, resulting in the anti- decline.

3.2.3 Effects of dipping bath ratio

As can be seen from Table 5, Figure 9 and Figure 10, when the cotton fabric is UV-resistant, the finishing effect is best when the ratio of the cotton fabric to the extract is 1:40. This is because the fabric bath ratio of 1:40, the Lithospermum extract is easy to adsorb on the surface of the fabric, the bath is not easy to contact with the small fabric is less than the adsorption rate is low, the bath is too large extract in the solution is too easy to disperse Adsorbed on the fabric surface.

Table 6. Effect of impregnation bath on cotton fabric performance.

Dipping Bath	Whiteness （%）	Transmittance Ave （%）		Anti-UV Performance （UPF）
		UVA	UVB	
Original	79.7	10.14	7.33	12.31
1：30	34.0	3.55	2.18	42.56
1: 40	31.6	3.2	1.84	46.52
1:50	32.8	3.37	1.96	44.73

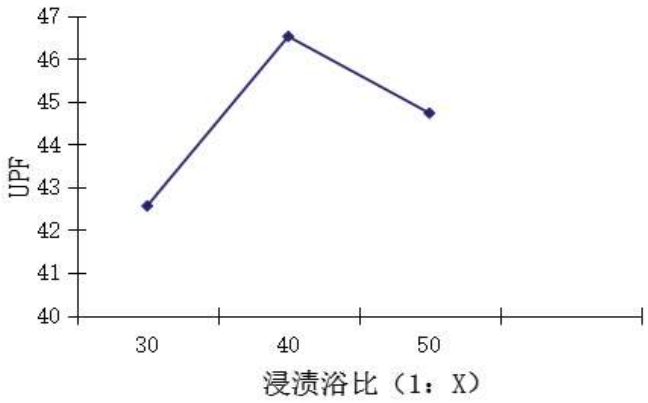

Figure 12. Relationship between anti-UV properties and dipping ratio of fabric.

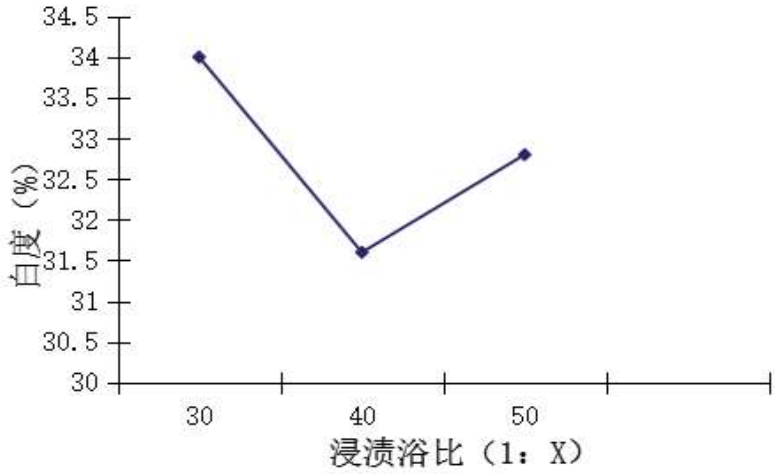

Figure 13. The relationship between the whiteness of the fabric and the bath ratio.

Comparison of the performance of cotton fabrics before and after finishing

In the best extraction process of Lithospermum and its anti-UV finishing of cotton fabric under the conditions of cotton fabric finishing before and after the performance changes in the following table. It can be seen from Table 7 that the whiteness of the fabric after the optimal process is reduced, the breaking strength is slightly reduced, the wrinkle resistance is improved, and the UV protection performance is improved to the best of the country.

Table 7. The performance of the original fabric and the fabric after the best process.

Sample	Whiteness （%）	Breaking Strength （N）	Rapid Recovery Angle （° ） (By+Latitude)	Slow Rebound Angle （° ） （By+Latitude）	Transmittance Average（%） UVA	UVB	UPF
Original Fabric	79.7	244	110	128	10.14	7.33	12.31
Finishing Cotton	20.1	239	121	132	1.02	1.22	85.60

3.3. Finishing cotton fabric anti-UV wash ability.

UV resistance is a very important indicator of the anti-UV effect of the fabric, mainly to wash the performance as an evaluation index. In the cotton fabric after the excellent processing conditions, refer to the Japanese standard JIS 0217 103 method: 2g / L of the washing powder washing solution, bath ratio 1:30, temperature 40 ℃, washing 5 min after dehydration, and then cold water 2 Min, dehydration drying, this is washed once. According to the washing standard after anti-UV treatment of cotton fabric 5,10 times washing, testing the cotton fabric after anti-UV performance and whiteness. It can be seen from Table 8, after finishing the cotton fabric anti-ultraviolet performance was significantly improved, after 5,10 times after washing, although a certain degree of decline, but still has a good anti-UV performance, indicating that after finishing the cotton fabric functionality with Good washability.

Table 8. Anti-UV wash ability of cotton fabric after finishing.

Sample	UPF
Original Fabric	12.31
Finishing Cotton Fabric	85.60
Wash 5 Times	83.12
Wash 10 Times	80.34

3.4. Finishing cotton fabric antibacterial

Studies have shown that Lithospermum has a good anti-bacterial anti-inflammatory, anti-virus, anti-tumor and other pharmacological effects. The strains used in this experiment are E. coli (Gram-negative Gram-negative bacteria) and Bacillus subtilis (Gram-positive Brevibacterium), is representative. Escherichia coli is a kind of bacterium which is very close to our daily life. It is a single cell organism which is harmless to the human body in the human body's large intestine. It is simple in structure, easy to breed and easy to cultivate. The medium was LB Broth Medium and the ingredients were yeast powder, Tryptone and sodium chloride. The medium was dissolved in deionized water to prepare a solution with a concentration of 25 g / L. The pH was adjusted to about 7.2 with NaOH, In the test tube, tighten the tampon, sterilize at 120 ℃, 0.6MP high temperature and high pressure for 15 minutes, remove it at 80 ℃, put it at 4 ℃, keep inoculation, and the medium is clear Light yellow liquid. Escherichia coli and Bacillus subtilis were inoculated on a clean bench. The ratio of cotton fabric sample to medium was 1:20, and the fabric-containing medium was inoculated in a shaking incubator at 37 ° C. Escherichia coli Cultured for 24 hours, Bacillus subtilis was cultured for 10 hours.

The raw cotton fabric and the better finishing process of cotton fabric samples were measured at 600nm, respectively, the measured absorbance, the measured values are as follows:

Table 9. Absorbance after each sample culture medium.

Strains	Original Fabric	Finishing Cotton Fabric
Bacillus Subtilis	0.932	0.198
Escherichia Coli	0.877	0.251

It has been shown that when the measured solution is thinner, its absorbance is proportional to the concentration, and then the concentration of the solution can be calculated from the absorbance value. The number of bacteria in each

solution can be calculated, and the amount of bacteria can be calculated Antibacterial rate. The inhibition rate of each sample is shown in the following table.

Table 10. Antimicrobial rates of samples for E. coli and Bacillus subtilis.

Finishing Cotton	Antibacterial Rate
Bacillus Subtilis	78.74%
Escherichia Coli	71.37%

From Table 9, it can be seen that the finished cotton fabric has a good bacteriostatic effect on Bacillus subtilis and Escherichia coli. This is because the Lithospermum has antibacterial, antiviral effect, Lithospermum extract shikonin, penta-pentenoic acid and other components, in vitro on Staphylococcus aureus, Bacillus subtilis, Escherichia coli and so have inhibitory effect.

4. Conclusions

The extraction technology was as follows: Lithospermum 4g, 95% ethanol 44ml, extraction temperature 60 ℃, extraction time 2h; Lithospermum extract anti-UV finishing, the optimization process: bath ratio 1:40, impregnation temperature 70 ℃, immersion time 2h.

The UV resistance of the cotton fabric treated with the extract of Lithospermum erythrorhizon was better than that before the finishing, and the UVA and UVB had good shielding effect. The UPF value increased obviously from 12.31 to 85.60 before finishing. Cotton fabric wrinkle resistance slightly improved, but the breaking strength and whiteness decreased. The antibacterial properties of the fabric were 78.74% and 71.37% for Escherichia coli.

References

1. Shang Chengjie. Anti-UV textiles [M]. Functional textiles, 2006: 201-231.
2. Yun Qiu. Anti-ultraviolet fiber and fabric [J]. Sichuan Silk, 2002 (02): 29-30.
3. Du Yanfang, Pei Chonghua. Anti-ultraviolet textiles research progress [J]. Knitting Industry .2007 (09): 23-27.
4. Sun Weiguo. Anti-ultraviolet fiber and textile [J]. Cotton Textile Technology, 2001 (05): 285-287.
5. Zhang Jianxiang, Ren Jizhong, Tian Lili, Wang Wei. Anti-UV composite finishing of cotton fabric [J]. Printing and dyeing .2010 (10): 29-31.
6. Zhang Yongjiu, Feng Aifen. Anti-ultraviolet finishing of cotton fabric. Proceedings of the 6th National Conference on Printing and Dyeing and Finishing, 2005, 11: 361 ~ 364.
7. Tang Zengrong. Textiles anti-ultraviolet finishing research [M]. The fourth post-finishing academic symposium Proceedings, 2005: 313-319.
8. Zhong Anhua, Qiu Peijiong, Wang Dong. Anti-ultraviolet radiation mechanism and its product development [J]. Auxiliaries, 2002, 19 (3): 43- 45.
9. Xu Pu. Anti-ultraviolet radiation mechanism and product research [J]. Cotton Textile Technology, 1999,27 (7): 16-19.
10. Yang Xiufang. Optimization of extraction process of Lithospermum erythrorhizon [J]. Journal of Shaanxi University of Science and Technology, 2004,22 (4): 60-61.
11. Longstreth J D. Efforts of increased solar ultraviolet radiation on human heal th [J]. A Journal of the Human Environment Research and Management. 1995, 24 (3): 153- 165.
12. Algaba D, Riva A, Crews P C. Influence of fiber type and fabric porosity on the UPF ofsummer fabrics [J] .AATCC Review, 2004, 74 (2): 26- 31.
13. Ignacoi Galindo. Ultraviolet in radiance over Mexico city [J]. Journal of Air Was the Management Association, 1995, 45 (11): 886-892.