Study on the UV-protective Ability and Camouflage Performance of Cotton Fabrics Dyed with Lithospermum

Lan Zhou[1,3], Jian-Zhong Shao[1,2*], Li-Qin Chai[1]

[1] *Engineering Research Center for Eco-Dyeing & Finishing of Textiles, Ministry of Education, Zhejiang Sci-Tech University, Hangzhou 310018, China;*
[2]*Key Laboratory of Advanced Textile Materials and Manufacturing Technology, Ministry of Education, Zhejiang Sci-Tech University, Hangzhou 310018, China*
[3] *School of textiles, Tianjin Polytechnic University, Tianjin 300160, China*

Abstract: UV-protection and near infrared camouflage are the two major camouflage protections in modern military tactics. However, not all natural and composite dyestuffs provide the above mentioned properties. In this study, green leaves were chosen as the simulating object, and the camouflage properties of cotton dyed with Lithospermum were evaluated. It was observed that the dyed cotton fabric had good UV-protection and near-infrared camouflage properties. The UV- protection effect was strongly dependent on the absorption characteristics of Lithospermum while absorbing UV radiations. The near infrared camouflage effect was mainly dependent on the reflection spectrum characteristics of Lithospermum in the near infrared waveband.

Keywords: Lithospermum, ultraviolet protection, near infrared camouflage, cotton.

1. Introduction

Ultraviolet radiation (UVR) is the major environmental cause for skin damage. UVB exposure to human skin induces skin alterations, including erythema, which is characteristic of sunburn cells, and prolonged UVB exposure results in the formation of wrinkles, the degradation of matrix molecules, the development of elastosis, and an increased risk of epithelial skin cancer. If all current exposure to solar UVR could be significantly reduced, the incidence of skin cancer would eventually decrease significantly [1,2]. So it is necessary to improve the UV-protection performance of the military uniforms.

The equipment of infrared camouflage uniforms with high performance not only increases the chance of survival and safety of soldiers in the battlefield, but also strengthens the battle effectiveness of the army. Through years, the art of camouflage has been long established, the main aim was to make soldiers, their guns, vehicles, etc. blend into the surroundings by adopting confusing patterns in colors appropriate to the surroundings. With the advent of IR detection systems it became necessary to take into account the IR reflectivity of paints and garments in the near IR region (700-1200 nm). Therefore, it became necessary for camouflage patterns to be painted or printed with selected dyes and pigments having IR reflectivity that matched the expected surrounding topography [3,4]. Now the study of UV-protection and infrared camouflage fabrics has
derived great attention in the military affairs across the world [5,6].

In previous years, the application of natural dyes in textile dyeing had been explored worldwide. In general, natural dyes are environmental friendly and nontoxic compared to synthetic dyes. They exhibit better biodegradability and have higher compatibility with the environment. Therefore, correlative research work on the application of natural dyes is globally under way [7-12].

Lithospermum has been traditionally used as a medicine in China and also as a dye for staining fabrics and food colorants. Previous phytochemistry studies reported that this plant contains mainly red pigments which were composed of naphthoquinone compounds, such as shikonin and its derivatives. However, previous research on Lithospermum had been focused on wound healing, antitumor, anti-fungus, anti-HIV and contraceptive biological activities [13-17] and little attention was paid to other functions such as UV-protection and near infrared camouflage.

In this paper, we studied the camouflage property of the cotton fabrics dyed with Lithospermum. The relationship between Lithospermum structure and camouflage property was discussed. It is believed that this study will pave a new way for the natural dyestuff development and provide a good insight into

*Corresponding author's e-mail: jshao198@yahoo.com.cn
JFBI Vol. 2 No. 3 2009 doi:10.3993/jfbi12200907

camouflage property of natural dyes.

2. Experimental

2.1 Experimental materials

Lithospermum root was purchased from the Chinese Traditional Medicine Hospital of Zhejiang. Plain weave cotton fabric was provided by Guangdong Yida Co. Ltd (China).

2.2. Experimental methods

2.2.1. Preparation of the fabrics

The plain weave cotton fabric was soaked in a detergent solution for about 60 mins, followed by extensive washing with tap water until free from any detergent. The clean fabrics were then washed with de-ionized water, squeezed, and allowed to dry in an air oven at 60 ℃, and were then stored in a vacuum desiccator ready for use.

2.2.2 Extraction of colorant

Before extraction of the dyestuffs, the plant materials were dried and ground to powder. In this experiment, the Lithospermum was crushed and dipped in distilled water for 24hrs and allowed to boil in a beaker kept over water bath for quick extraction for 1h. All the colors were extracted from the plant by the end of 1hr. The solution was filtered for further use.

2.2.3 Dyeing

The dyeing procedures were performed in accordance with the general dyeing method. A ratio of dyestuff to fabric of 1:10 was chosen based on the weight of the fresh natural dyes extracted from the fabrics used in the experiment. The fabric was immersed in a dye-bath composed of 0.25% aqueous solution of the dye. The dye liquor ratio (1:40) was kept constant for all samples. The temperature of the dye bath was then gradually raised (about 1 ℃/min) to about 90℃, and was kept at this temperature for about 60 mins. The temperature of the dye-bath was then allowed to cool to about 60℃; then the dyed fabric was squeezed, rinsed thoroughly with water and air dried.

2.2.4 UV-protective properties and camouflage performance testing

The ultraviolet light transmittances of un-dyed and dyed fabrics were determined using the Lambda 900 UV/Visible/NIR spectrometer in the range of 280-400 nm. The UPF standard in this paper was referred to the As/ NZS 4399-1996.

The IR reflectivity of the samples in the near IR wavebands (700-1200 nm) was determined using the Lambda 900 UV/Visible/NIR spectrometer. The pattern painting camouflage reflectance spectrum evaluation was referred to the American military standard HIL-C-44031D 1989.8.22.

3. Results and Discussion

3.1 Ultraviolet transmittance spectra

In order to investigate the UV-protective property of Lithospermum, the ultraviolet transmittance spectra of the un-dyed fabrics were compared with those of the dyed fabrics. As shown in Fig. 1, there was a noticeable difference between the dyed fabrics and the un-dyed fabrics in terms of ultraviolet transmittance spectra. The un-dyed fabrics had a higher ultraviolet transmittance, which was above 15% in the UV-B band (280-315nm) and above 25% in the UV-A band (315-400nm). This indicated that the resistance of un-dyed fabrics to ultraviolet rays was very poor. Meanwhile, the ultraviolet transmittance of the fabrics dyed with Lithospermum was lower than 1 % in both UV-A and UV-B bands. Generally, the UV-protective properties of fabrics are considered good when the ultraviolet transmittance is less than 5 %. It was evident that the good UV-protective properties occurred in cotton when it was dyed with Lithospermum.

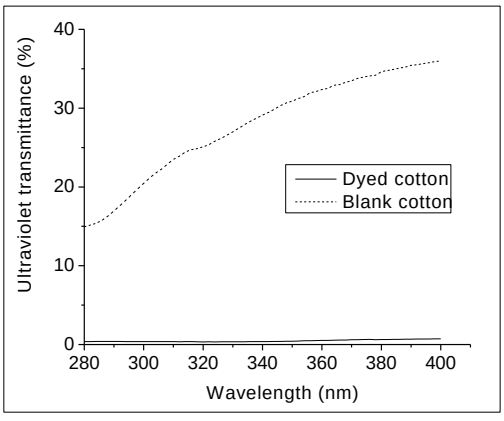

Figure 1. Ultraviolet transmittance spectra of the fabrics dyed with Lithospermum.