

Creating Ultraviolet protective clothes using natural dyeing

Nagah S. Ashour a and O. K. Ahmed a

Faculty of women for Art, Science and Education, Ain Shams University, Cairo, Egypt

Abstract:

Exposure to ultraviolet (UV) radiation from the sun can cause skin damage including sunburn, blistering, skin ageing and in the long term can lead to skin cancer. Natural dyeing plays an important role to imparting new functional properties (Ultraviolet protection) into the dyed substrate. In this research wool fabric dyeing with Rhine-M, Pacific, Thar, Kango and Basant natural dyes and evaluated ultraviolet radiation in terms of ultraviolet protection factor values which give excellent values. Color strength (K/S) was investigated and gives high values. The fastness properties of dyed wool fabric against washing, light, and perspiration were evaluated and the result show very good values. Physico mechanical was investigated and there is no negative effect on them. Fashionable five designs were created for women clothes using natural dyed fabric, which has ultraviolet protection properties. Tie and dye technique was used to dyed designs. Add aesthetics value by using stitching, drawing and embroidery.

Keywords:

Natural dye
women clothes
UPF
wool fabric
functional dyeing.

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Introduction:

Ultraviolet (UV) radiation in the spectral region from 280 to 400 nm is present in the solar system and causes health problems such as sunburn, allergies, and even skin cancer. More frequent reports of skin cancer have made people increasingly aware of the danger of prolonged exposure to ultraviolet rays, which account for about 6% of the terrestrial sunlight and under excessive doses is proved to cause erythema, certain skin cancer, keratitis, and cataracts.^(1,7,8,14)

Human exposure to UV radiation has increased in recent years due to altered leisure habits and to higher overall levels of UV caused by the decreased ozone content of the atmosphere. Therefore there is strong demand for means of providing UV protection. Textile plays an important role as it is directly applied to the skin, when the ultraviolet radiation hits the textile materials, different types of interaction occur depending upon the substrate and its conditions. The UV protection by textile materials and apparels is a function of the chemical characteristics, physico-chemical type of fiber, presence of UV absorber, fabric construction, thickness, porosity, extension of the fabric, moisture content of the fabrics, color and the finishing given to the fabric.^(2,5)

UV radiation degrades the textile materials, as a result of excitations in some parts of the polymer molecule. Much depends on the type of fiber and

its chemical structure. Due to large surface area available, textile fabrics are more susceptible to attacks by UV radiation. Natural fibers like cotton, silk and wool have lower degree of ultraviolet protection absorption than that for synthetic fibers.⁽³⁾

One of the most important elements in preventing skin cancer is the use of comfortable UV-protective clothing. The UPF of Wool doesn't provide adequate protection for outdoor wearers, so clothing with a greater UPF should be worn.

Creating an effective design involves the elements of design; color, shape, line and texture; they are the building blocks of design. The principles of design are balance, proportion, emphasis, rhythm and harmony. They are guidelines for use of the elements of design.^(6,10)

Clothing is a basic human need that traditionally is viewed as a means of satisfying the aesthetic needs of fashion, but today the need for fashion has been combined with a critical need for function. Clothing is a portable environment that is carried everywhere with an individual.⁽¹⁵⁾

One approach to clothing design that has emerged as recognizing the need for function as well as fashion in functional clothing design. In the functional design process, the attractive visual effects are worthless if a garment is uncomfortable or does not perform its function. Using functional design process, a garment designed for occupational safety will be well designed in three

aspects: function, structure and aesthetics or decorative. The successful garment must be designed in these aspects, where they all blend together, unify and seem naturally complementing each others. ⁽¹⁵⁾

So, this study aims to enhance the dyeing properties of protein-based textile with natural dyes, impart new functional properties into the dyed substrates and create fashion designs for women.

2. Experimental:

2.1. Materials:

2.1.1. Fabric:

A plain weave 100% wool fabric of 146 g/m²

having 25 ends / cm and 24 picks / cm was used in this research.

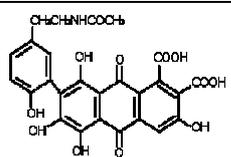
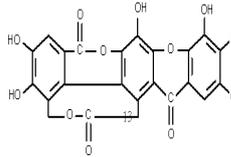
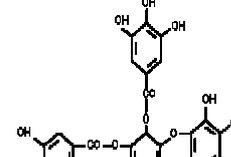
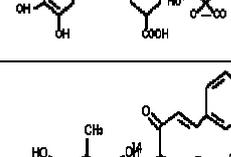
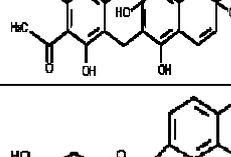
2.1.2. Chemicals:

Copper sulphate, potassium aluminum sulphate, potassium dichromate, ferrous sulphate, sodium sulphate, sulfuric acid, acetic acid, phosphoric acid and formic acid were of laboratory grade chemicals.

2.1.3. Dyes:

Commercial samples of natural dye powders were obtained from ALPS Industries Ltd, Sahibabad. Indian. Specifications of these dyes are listed in table (1)

Table (1) Natural dyes used

Common name	Botanical name	Commercial name	C.I.	λ_{max} (nm)	Chemical structure
Lac	Lacifer Lacca	Rhine-M	Natural red 25	530	
Anar Chilka	Punica granatum	Pacific	Natural yellow 7	400	
Harda	Terminalia chebula	Kango	Natural brown 6	400	
Kamala	Mallotus philippinensis	Basant	Natural yellow 25	400	
Cutch	Acacia catechu	Thar	Natural brown 3	440	

2.2. Methods:

2.2.1. Dyeing method

The wool fabric is added to an aqueous solution of dye bath which contain dye (3 to13 % o.w.f.), different type of acids (sulfuric acid, formic acid, acetic acid and phosphoric acid), with different concentration (1 to 5 % o.w.f.), sodium sulfate (8 to 16 % o.w.f.) , mordant (2 to 10 % o.w.f.) , at different temperature (R.T. to 100⁰C) , for different periods of time (30 to 90 min.) and using L:R 1:50.

At the end of dyeing, the samples were washed in an aqueous solution containing 5g/L nonionic detergent at 60°C for 15 minute. Finally the samples were washed with warm water, then with cold water, and dried at ambient condition.

2.3. Testing and analysis:

2.3.1. Color strength (K/S) :

Color strength (K/S) of the dyed samples was measured on Mini Scan XE spectrophotometer using Hunter lab universal soft ware, which based on Kubelka – Munk equation.

$$K/S = (1-R)^2/2R$$

Where: K, S, and R are the absorption coefficient, scattering coefficient, and reflectance, respectively.

2.3.2. Ultraviolet protection factor (UPF) evaluation:

In vitro testing measures ultraviolet (UVR) transmission and the ultraviolet protection factor (UPF) was calculated according to the Australian/New Zealand Standard (AS/NZS-4399-1996) using UV-Shimadzu 3101-PC-Spectrophotometer.⁽⁴⁾

2.3.3. Fastness properties:

The light fastness, wash fastness and fastness to perspiration of dyed samples were determined according to ISO 105-B02:1999, ISO (1B.S.2680-1961), and AATCC 15. 1997, standard test methods respectively.

2.3.4. Physico mechanical measurements:

Stiffness, Thickness, the tensile strength and elongation and Tearing resistance of dyed fabrics were measured according to ASTM (-D-1388-96-2002), ISO (3616-2001), ASTM (-D- 1682-64-1970), ASTM D/1424-96-2002 respectively.

2.4. Pattern and Layout:

The patterns of the women designs have been drawn as described in metric cutting.⁽²⁰⁾

3. Results and Discussion:

3.1. The properties of ultraviolet protective clothes

There are principles of sun protect clothing. These principles are:

- Sun protective clothing should be casual, loose, cool and comfortable to protect babies, children, outdoor activity workers, some public service workers and outdoor employees.
- Wear lightweight and loose off fitting clothing.
- Cover up, ordinary clothing made from close-woven fabric.
- Ease of putting on and taking off: openings and fastening systems/speed of operation.
- Appropriate form, style, materials and color (overall concept and silhouette). The garments should cover or shade the greatest skin area is better choices. These include hats, shirts with collars and long sleeves, trousers with long legs, and skirts that are knee length or longer. For many individuals, this is just too much fabric, too confirming and not appropriate to the occasion. This is the time to complement garment selection with sunscreen lotion.
- Structural seams darts, gathers, double layer cuts and facing, style, fit and ease of movement.
- Aesthetic elements: color, appearance, handle, touch comfort on skin.

- Details and features: zippers, buttons and accessories.^(16, 17)

The techniques used in this research are described briefly as given below

3.2. Tie and dye technique:

The words tie and dye describe the two operations of a resist dye method of decorating fabric. First, the fabric or parts of fabric are tied tightly so that dye can not reach, or can only partially reach, the bound areas. Then the fabric is dyed. There are many variation of tying, knotting, folding, bagging, stitching, gathering, etc., which will resist out dye penetration.^(12,19) The fabric should have a pattern of dyed and undyed, or lightly lines and/or shapes, which is characteristics of the process. White or off white fabrics take dye colors more clearly and accurately than colored fabrics.^(9,11,18) Dyeing technique in which the fabric or garment is tightly folded and tied at intervals with rubber bands. When submerged in dye, only the exposed sections are affected, creating a distinctive pattern.⁽¹³⁾

3.2.1. Circles:

The most common tie and dye pattern is the circle. The fabric is pulled into a point from a central position and bound in sections down its length. By adding additional bindings and over dyeing the fabric further patterns can be produced, as shown in designs (1),(5).^(9,19)

3.2.2. Strips and squares:

A regular striped effect can be produced if fabric is knotted with a simple overhand knot along its length and then dyed. Strips that are more regular can be created in horizontal, vertical or diagonal directions by pleating or rolling the fabric tightly and then binding sections to stop the penetration of the dye. Bindings of the same thickness at regular intervals will produce an even striped effect, and irregular bindings will produce a varied stripe, as shown in designs (3) and (4).^(11,13) A square shaped dot is made by pulling the cloth up into a point and folding it in half, this is repeated before binding with a series of knots, as shown in design (3).^(9,18)

3.2.3. Introducing more colors:

In this technique more binding is added and then redyeing. It must take into account that unite is not recommended at each end of each dyeing, as shown in designs (2), (4).⁽¹⁹⁾

3.3. Stitchery:

Stitchery may be defined as a method of ornamenting a fabric or an article. Embroidery is a type of stitchery in which the article is ornamenting using stitches made thread by using needle. Embroidery is one of many good methods



Design (2):

Width: 160 cm (woven wool fabric)

Length: 204 cm **Layer:** two layers

Layout: (1- upper part of front yoke, 2- lower part of front yoke, 3- front of dress, 4- front inform, 5- upper part of back yoke, 6- lower part of back yoke, 7- back of dress 8- back inform, 9- front and back of dress , 10- sleeve).

● **Functional aspects:**

The function element in this design achieved through the elbow length sleeve which protects the entire arms area. The narrow semi square neck opening protects its area. The under knee

length and addition to the wide hem support more freedom in movement the design imparts good covering and protection to the entire body area.

● **Structural aspects:**

They are shown in the design appearance via semi square neck line that allows ease of wearing the dress. The curved line and cuts in the bodice area moving the eye vertically and horizontally up and down without interruption.

● **Aesthetical aspects:**

The decorative elements were achieved in the design through the curved cuts in the bodice with their attractive yellow and dark red colors, which mixed together producing smooth transition passage and harmony to each other. In addition to embroidered stitches around neck and sleeve hem catch the eye supporting the decorative appearance. Using hand embroidery stitches with a bright contrast color create formal, balance, good rhythm, as well as emphasis that attracts attention all over the design.

The application of design (2):

Fabrics:* Woven 100% Wool (plain 1/1)

Dyes: * Rhine-M natural dye
* Basant natural dye

K/S: Rhine-M → 16.382

Basant → 10.635

UPF: * +50

Techniques:* Tie and dye
*Embroidery stitches

Fastness properties of wool fabric dyed with Rhine-M and Basant dyes

Dye name	Washing fastness			Light properties	Perspiration fastness			
	Color change	Staining on	Staining on wool		Alkali		Acid	
					on nging Stai	ning Stai	on nging Stai	ning Stai
Rhine-M	4	5	3-4	5	4-5	4-5	4-5	4-5
Basant	4-5	3-4	3-4	3-4	4-5	4-5	4-5	4-5

Physical properties of wool fabric dyed with Rhine-M and Basant dyes

The sample	Fabric thickness (mm.)	Fabric stiffness (m g/m)	Resistance to tearing (kg)	Tensile strength (kg/cm)	The elongation %
Blank sample	0.49	1.26	2555	27.3	63



Wool fabric dyed with Rhine-M dye	0.51	1.53	2533	27.8	67.3
Wool fabric dyed with Basant dye	0.53	1.25	2500	28.4	66.3



dress. The function elements in this design were represented in neck opening with Chinese collar that protecting its area. The long sleeves with box pleat in the dress provide covering to arm area. The length of the dress (under knee) provides safety and comfort. The whole design functionally adds value via supporting good protection of the garment system as well as reflects fashion and life style trends.

● **Structural aspects:**

The buttons in the upper part of dress were used for decoration only; they express the two colors of the design (off white and dark red). The diagonal and curved lines in cuts produce asymmetric balance. These diagonal and vertical lines move the eyes through the entire dress. In addition to the structural aspects of Chinese collar completes the harmony of this design by repeating the curved lines.

The application of design (3):

Fabrics: * Woven 100% Wool (plain 1/1)

Dyes: * Rhine-M natural dye

K/S: 16.382 **UPF:** * +50

Techniques:

* Tie and dye

*Leathering strips adding

Design (3):

Width: 160 cm (woven wool fabric)

Length: 118 cm **Layer:** one layer

Layout: (1-front yoke, 2- front of dress, 3- front of dress, 4- front neck inform, 5- back neck inform, 6- back of dress,7- front of dress 8- officer collar, 9- collar facing , 10- sleeve of dress, 11- sleeve of dress, 12- cuff of sleeve, 13- cuff of sleeve).

● **Functional aspects:**

This design is an off white and dark red

Fastness properties of wool fabric dyed with Rhine-M natural dye

Dye name	Washing fastness			Light properties	Perspiration fastness			
	Color change	Staining on cotton	Staining on wool		Alkali		Acid	
					Staining on cotton	Staining on wool	Staining on cotton	Staining on wool
Rhine-M	4	5	3-4	5	4-5	4-5	4-5	4-5

Physical properties of wool fabric dyed with Rhine-M natural dye

The sample	Fabric thickness (mm.)	Fabric stiffness (m g/m)	Resistance to tearing (kg)	Tensile strength (kg/cm)	The elongation %
Blank sample	0.49	1.26	2555	27.3	63
Wool fabric dyed with Rhine-M dye	0.51	1.53	2533	27.8	67.3



Design (4):

Width: 160 cm (woven wool fabric)

Length: 152 cm **Layer:** one layer

Layout: (1-front of blouse, 2- back of blouse, 3- front and back yoke of blouse, 4- front of blouse inform, 5- back of blouse inform, 6- sleeve, 7- sleeve 8- cuff of sleeve, 9- cuff of sleeve, 10- upper part of front skirt, 11- lower part of front skirt, 12- front skirt inform, 13- upper part of back skirt, 14- lower part of back skirt, 15- back skirt inform).

● **Functional aspects:**

This design is asymmetrical blouse and skirt. The long sleeve of blouse gives excellent U.V protection.

Although the skirt in this design is short, the

protection against U.V can be achieved by wearing boots.

● **Structural aspects:**

The interesting diagonal shape of neck line gives the wearer comfort to put on and take off. Repeating this diagonal line in the cut line and hem skirt line complete the harmony of the design. Also repeating flared shape of blouse by the structural cut line in sleeve give a good rhythm to the design.

● **Aesthetical aspects:**

The feminine feeling is the first impression for this design, which emphasis with curved diagonal lines, flared skirt and gathering in sleeve and in the upper part of blouse. The asymmetrical balance in this design draws the eye attention and makes the design to be more interest. The good distribution of the warm yellow color and neutral grey color give a pleasant harmony to the design. Using the decorative hand stitches in grey color emphasis the grey color in the design and completes the harmony and unity of the design.

The application of design (4):

Fabrics: *Woven 100% Wool (plain 1/1)

Dyes: * Kango natural dye
* Basant natural dye

K/S: Kango → 13.865
Basant → 10.635

UPF: *+50

Techniques: * Tie and dye
* Embroidery stitches

Fastness properties of wool fabric dyed with Kango and Basant natural dyes

Dye name	Washing fastness			Light properties	Perspiration fastness			
	Color change	Staining on cotton	Staining on wool		Alkali		Acid	
					Staining on cotton	Staining on wool	Staining on cotton	Staining on wool
Kango	4-5	4-5	4	5-6	4-5	4-5	4-5	4-5
Basant	4-5	3-4	3-4	3-4	4-5	4-5	4-5	4-5

Physical properties of wool fabric dyed with Kango and Basant natural dyes

The sample	Fabric thickness (mm.)	Fabric stiffness (m g/m)	Resistance to tearing (kg)	Tensile strength (kg/cm)	The elongation %



Blank sample	0.49	1.26	2555	27.3	63
Wool fabric dyed with Kango dye	0.52	1.33	2100	27.3	62
Wool fabric dyed with Basant dye	0.53	1.25	2500	28.4	66.3

Design (5):



Width: 160 cm (woven wool fabric)

Length: 160 cm

Layer: one layer

Layout: (1- front of dress, 2- front of dress, 3- front inform, 4- completed part of front inform, 5- front neck inform, 6- back of dress, 7- back neck inform 8- dress sleeve, 9- dress sleeve, 10- sleeve inform, 11- sleeve inform).

● **Functional aspects:**

This is a fashionable dress with off white and olive green colors. The long white sleeve and double layers of the dress impart more protection for the body creating a type of insulating against harmful radiation.

● **Structural aspects:**

The structural aspects were presented in this design, the curved neck line shape, which gives easily wearing as well as freedom in addition to its asymmetrical attractive shape. The orange button is used in this design for attached the two layers of the front as the structural aspect, also it is used as aesthetical aspect by repeating the orange color of decorative stitches.

● **Aesthetical aspects:**

The corporation between the female shape and loose shape impart a fashionable look to this design. Using the curved lines in the upper layer and the neck line expresses the feminine and smooth feelings. Repeating the big circle in the side of the dress by using a small orange button, gives a good rhythm and allows the eye to move through the design from up to down or otherwise. Hot orange (herringbone stitches) and cold olive green colors form a powerful combination. They vibrate like fire and ice. Powerful combination symbolizes the strongest emotion & control and sends a message of vitality, awareness and attracts attention to the design.

The application of design (5):

Fabrics:* Woven 100% Wool (plain 1/1)

Dyes: * Pacific dye

K/S: 17.629

UPF: * +50

Techniques:* Tie and dye * Embroidery stitches

Fastness properties of wool fabric dyed with Pacific dyes

Dye name	Washing fastness			Light properties	Perspiration fastness			
	Color change	Staining on cotton	Staining on wool		Alkali		Acid	
					Staining on cotton	Staining on wool	Staining on cotton	Staining on wool
Pacific	4-5	5	4	5-6	4-5	4-5	4-5	4-5

Physical properties of wool fabric dyed with Pacific dyes

The sample	Fabric thickness (mm.)	Fabric stiffness (m g/m)	Resistance to tearing (kg)	Tensile strength (kg/cm)	The elongation %
Blank sample	0.49	1.26	2555	27.3	63
Wool fabric dyed with Pacific dye	0.53	1.3	2300	28.5	65.3

4. Conclusion:

It was found that the Rhine-M, Pacific, Kango, Basant and Thar natural dyes have functional UV protective on a wool fabric. On the other hand the dyeing with this dyes did not has negatively effect on the physico mechanical properties and the fastness properties. Decrease negative imparts on the environment, dyers as well as end-users. Creating protective clothes that designed in aspects, function, structure and aesthetics or decorative is a new trend.

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