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# Ecofriendly Dyeing of UV-Irradiated Cotton Using Extracts of *Acacia nilotica* Bark (Kikar) as Source of Quercetin

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Increasing awareness about safe products in textiles has developed the worldwide choice in natural colour based textiles. For the present study, barks of *Acacia nilotica* (Kikar) has been selected as source of natural flavone dye (querecetin). Both cotton fabrics and dye powder were exposed to UV radiations for 30, 45, 60, 90 and 120 min. Later on the dye was extracted using irradiated (RP) and un-irradiated dye powder (NRP) followed by dyeing of irradiated (RC) and un-irradiated fabric (NRC). Different dyeing variables such as temperature, time, pH, liquor concentration (M:L) and electrolyte concentration were optimized and dyeing was performed at these optimum coniditions. To improve colour strength and colour fastness properties different concentrations of mordants such as Cu (copper sulphate), Al (aluminum sulphate), Fe (iron sulphate) and tannic acid were employed. ISO standard methods were employed to determine the colour fastness to light, washing and rubbing to observe the effect of UV radiation on these fastness properties. The fabrics investigated in CIE Lab system using spectraflash showed that exposure for 90 min modifies the surface of fabric and dyeing for 50 min at 55 ºC, using 8 g/100 mL of salt using dye bath of pH 6 provides the best colour strength. It is also found that iron is the best mordant among other used that improves the colour fastness properties from moderate to good.

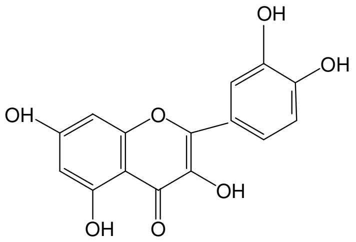
**Keywords: *Acacia nilotica*, Cotton, Colourfastness, Flavone dye, Mordanting, Quercetin, Spectraflash, UV irradiator.**

## INTRODUCTION

Today the main aspects in the selection of textile products that they should be non-toxic, have safe starting materials and finished products. The synthetic dyes contain toxic and carcinogenic chemicals that may lead to health hazards and cause water pollution[1,2]. The eco-standards narrated by different environmental agencies such as Environmental Protection Agency (EPA) and Food and Agriculture Organization (FAO) *etc*., have compelled the textile customers to choose the eco-label products[3]. Hence, there is a demand for natural dyes which are renewable, bio-degradable and eco-friendly. So increasing awareness of the society about the environment and health hazards associated with the synthesis of synthetic dyes have created a worldwide interest in natural dyed textiles. These natural colourants are non-allergic and non-toxic to human body[4,5]. Natural dyes showed better biodegradability and have higher compatibility towards environment due to which they are attracting the attention around the globe[6].

Different methods have been employed to improve extraction of colourant as well as surface modification of cotton fabric. Of such methods, radcure technology, particularly UV radiations offer an alternative commercial application for modification of surface of cotton. The use of UV radiation to improve the surface properties of fabric especially cotton fibers, offers an alternative application with commercial potential. Only limited studies have been done by researchers to use UV radiation for improving the dyeing ability of cotton using different type of natural dyes[7,8]. The role of radiation is increasing due to its well known advantages such as cost and labour effectiveness as well as high treatment speed. UV radiation can improve the value of dyeing and printing. The UV modification of surface fiber can allow more dye to be fixed, gives deeper shades and can improve wettability of fabrics[9,10]. It increases the printability of the fabric and reduces pilling as well as improve water repellent properties of cotton.

In present study, we have selected barks of *acacia nilotica* as a source of natural dye. *Acacia nilotica* is a genus of shrubs belonging to the sub-family Fabaceae. Commonly it is known as 'Babul' or 'Kikar' and contains more than 1300 species around the globe. Its bark being rich in phenolics such as tannins, quercetin, catechin *etc.* is used in dyeing and cosmetics as well as for treatment of different disease such as diarrhea, eczema, leucorrhea, cancer, tuomours, small pox, skin eruptions, leg sores, diabetes, mouth ulcers, *etc.*[11]. The structure of main colouring component (quercetin) present in the bark of *Acacia nilotica* is given below:



Quercertin

## EXPERIMENTAL

Fresh bark of *Accacia nilotica* (known as Kikar) a great source of natural colourant was obtained from Government College University, Faisalabad, Pakistan. Plain woven, bleached and mercerized cotton obtained from Noor Fatima Fabrics Mills, Faisalabad, Pakistan. The bark was chopped into small pieces, washed, dried and ground finely. The powder was passed through a sieve of 20 meshes to get uniform particle size. This powder was stored in opaque and airtight plastic jars for further experiment. All the chemicals used during extraction, dyeing and mordanting were of analytical grades.

**Irradiation and extraction process:** Both cotton and bark powder were exposed to UV irradiation (254 nm, 180 Watt) for 30, 45, 60, 90 and 120 min at Department of Applied Chemistry, GC University, Faisalabad, Pakistan[7,12]. The aqueous and alkali solubilized extracts were obtained from irradiated (RP) and un-irradiated powder (NRP) obtained by keeping material to liquor ratio (M:L, 1:30) at boiling for 1 h prior to dyeing[13].

**Optimization of dyeing and mordanting process:** After getting optimum extraction and exposure time, it is necessary to find optimum dyeing variables. For this purpose, dyeing was carried out at 30, 40, 50, 60 and 70 ºC to get optimum dyeing temperature. In another experiment, dyeing time was carried out for 25, 40, 55, 60 and 70 min. Similarly pH of dye bath was optimized at 5, 6, 7, 8 and 9 using acacia bark extract. To optimize the extract concentration 1:10, 1:20, 1:30, 1:40 and 1:50 of M:L was used. While to achieve maximum exhaustion, dyeing was carried out using different salt concentrations of 2, 4, 6, 8 and 10 g/100 mL. The optimized dying variables were used for dying and mordanted to enhance the colour strength and colour fastness properties. To improve colour strength and colourfastness, 2, 4, 6, 8 and 10 % of Cu, Al, Fe and tannic acid as pre and post mordants were employed at 60 ºC[14,15]. These dyed fabrics washed with distilled water, dried at room temperature and sent to CIE lab system for the evaluation of colour strength properties.

**Measurement of colour characteristics of dyed fabrics:** The effect of UV radiations on colour fastness properties of irradiated fabric dyed with *Accacia nilotica* bark extract were determined by ISO standard methods such as ISO-CO3 for washing, ISO 105X-12 for rubbing and IISO 105 BO2 for light fastness. All the dyed samples were sent to CIE Lab system using spectrophotometer SF 650 at D 6510º observer. The wash fastness was employed using rota wash, rubbing fastness was determined using crock meter and light fastness was measured using fadometer[16].

## RESULTS AND DISCUSSION

It is found that UV radiation has a remarkable effect in dyeing, but it has no such significant effect on powder for extraction of dye. However the dye extracted in aqueous media gave more colour strength as compared to the dye extracted in alkaline medium. As colourant is acidic in nature, during extraction in alkali medium, there might be neutralization of colourant occurred, which upon dyeing showed less affinity with fabric and imparted dull shades with low colour strength as shown in Fig. 1(a,b).The surface modification of fabric by UV radiation causes changes in apparent structure of cellulose *i.e.*, conversion of C-OH group in to COOH, which develop more interaction with dye molecules[10]. The data given in Fig. 1(a-b) shows that fabric modification after 90 min gives good colour strength using aqueous extract. Hence optimum condition for extraction is un-irradiated powder (NRP) using aqueous medium for dyeing of irradiated cotton (RC, 90 min).

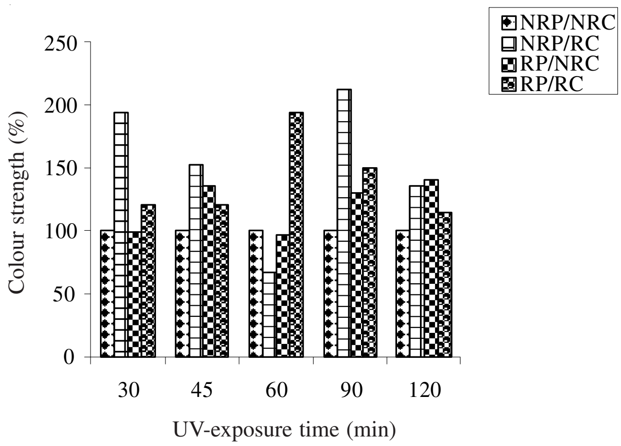



Fig. 1. (a) Effect of UV radiation on extraction and dyeing of acacia bark powered and cotton using aqueous media

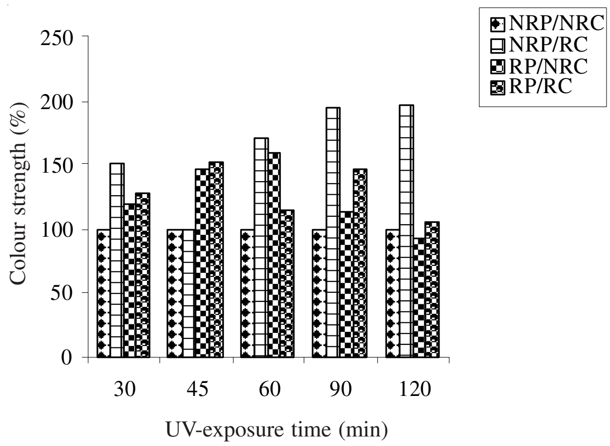



Fig. 1. (b) Effect of UV radiation on extraction and dyeing using alkaline media

When a cellulosic fabric is dyed with natural colourant, the amount of dye sorbed on fabric depends upon its temperature. At low temperature dye molecules are not activated to sorb on to fabric while at high temperature either colourant may be degraded or clusters of dye molecules gather on surface may start desorbing and gives poor shades[12]. Same is the case has been seen in our studies. At 50 ºC the colourant sorbs evenly on irradiated fabric (RC) and upon investigation in spectraflash show good colour strength and darker shades as shown in Fig. 2. Hence 50 ºC is the optimum dyeing temperature.

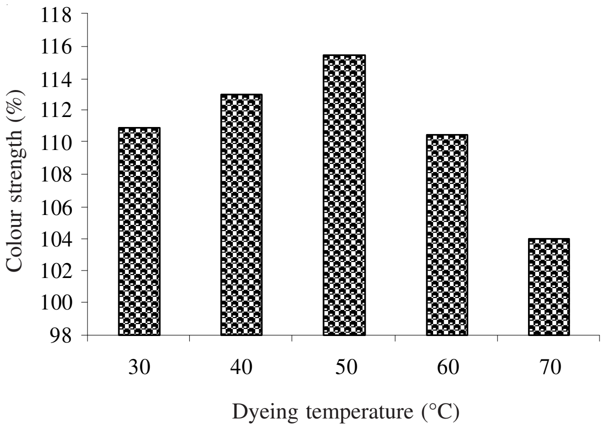



Fig. 2. Effect of dyeing temperature on the colour strength of irradiated cotton (RC) using aqueous extract of un-irradiated acacia bark powder

Data shown in Fig. 3 expressed that dyeing for 55 min is the optimum time using irradiated fabric (RC, 90 min) dyed with extract of un-irradiated powder (NRP). Dyeing for low time causes sorption of less amount of colourant onto fabric, while dyeing for long time may shift the equilibrium from fabric to dye bath[17]. After dyeing upon investigation in spectraflash, the fabric dyed for long time and short time show dull shades with low colour strength. Hence optimum dyeing time is 55 min.

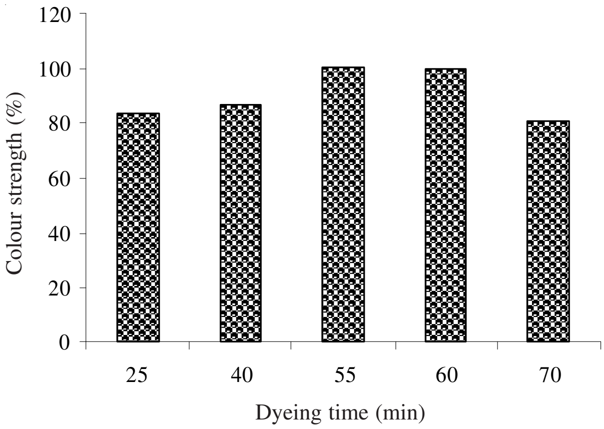



Fig. 3. Effect of dyeing time on the colour strength of irradiated cotton (RC) using aqueous extract of un-irradiated acacia bark powder

Fig. 4 shows that dyeing under mild acidic condition is suitable to get good colour strength with darker shades. While in basic medium, dye molecules may face neutralization and may not sorb firmly onto the fabric surface. On washing the colourant may detach and show less strength. Hence pH 6 of dye bath is optimum value[1].

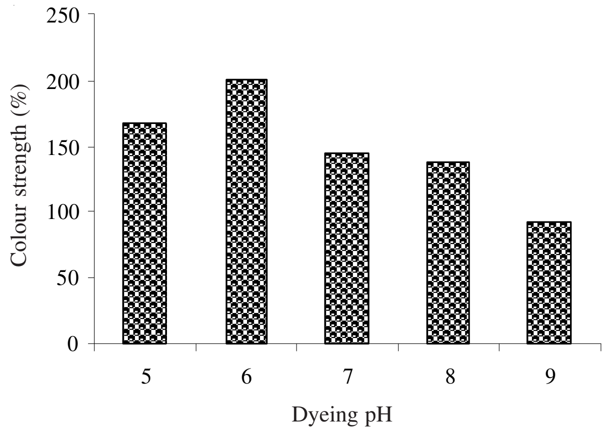



Fig. 4. Effect of dyeing pH on the colour strength of irradiated cotton (RC) using aqueous extract of un-irradiated bark powder

The graphical data represented in Fig. 5 shows that M:L 1:40 is the optimum amount of dye used for dyeing of irradiated fabric. Too low amount of dye used may causes unevenness due to presence of insoluble impurities while too high concen-tration may cause gathering of clusters of dye molecule onto fabric resulting in unevenness. Hence even dyeing is achieved using material to liquor of 1: 40 onto irradiated fabric (RC)[6].

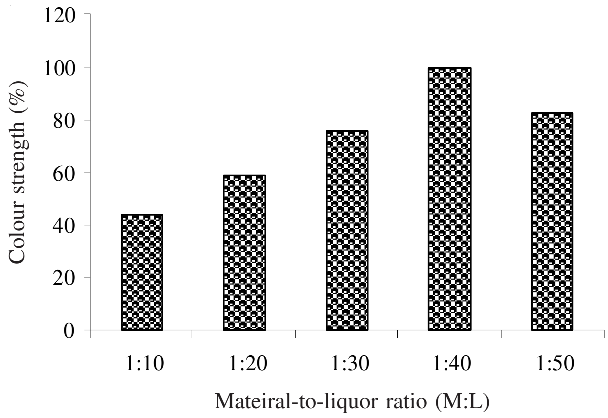



Fig. 5. Effect of extract concentration on the colour strength of irradiated cotton (RC) using aqueous extract of un-irradiated bark powder

The experimental data given in Fig. 6 reveals that 8 g/100 mL using Glauber's salt is optimum amount as compared to table salt as exhausting agent. Previously it is reported that when fabric is immersed in water, it acquires negative charge and that charge upon dyeing is repelled by negative ions. When such agents are used they try to overcome repulsion and causes maximum exhaustion of dye from bath to fabric *i.e.*, due to formation of H-bonds or other interactions between fabric and dye[18]. Hence using too low amount and too high amount of salt does not shift the dye equilibrium properly towards fabric and after dyeing show dull shades. Hence 8 g/100 mL of Glauber salt is the optimum amount.

Data displayed in Fig. 7(a) for pre-mordanting show that iron is the best mordant than Cu, Al and tannic acid used. It can be seen that UV radiation of fabric for 90 min has reduced the amount of mordant used. This is due to formation of dye complex with mordant on fabric. Iron forms more firmed complex as compared to Al, Cu and tannic acid. Similarly the

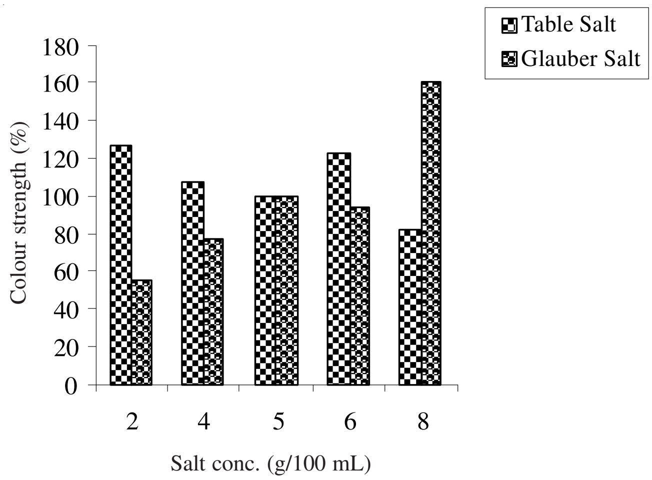



Fig. 6. Effect of salt concentration on the colour strength of irradiated cotton (RC) using aqueous extract of un-irradiated bark powder

data given in Fig. 7(b) also shows that 4 % of iron gives maximum colour strength onto irradiated fabric. Hence optimum mordant is iron for improving good colour strength and fastness properties.

The rating results of colour fastness properties given in Table-1 shows that UV radiation has improved from poor to good, if fabric is exposed for 90 min using aqueous extract of un-irradiated powder at optimum dyeing conditions. The improved colour fastness properties might be due to presence of benzene ring and conjugated system in the colourant[19]. The other factor depends upon the metal dye complex formation and its bonding with surface modified fabric (RC, 90 min). When this fabric is exposed to agencies such as light, heat, detergent and rubbing show less resistance to detach and give good fastness. Hence it is proved that UV radiation has a potential to improve colour fastness properties.

## Conclusion

The natural dye extracted from Acacia bark powder can be used as a possible substitute of synthetic dyes, while the use of UV radiation in surface modification of cellulosic fabric also offers an alternative commercial potential. Extraction of dye from un-irradiated powder (NRP) and its application onto irradiated fabric (RC, 90 min) at 50 ºC for 55 min using 8 g/100 mL of exhausting agent with material to liquor ratio of 1:40 gives maximum colour strength. Furthermore Iron as pre and post mordant with 4 % solution has improved the colourfastness properties from poor to good. It is found that such radiations are useful in application of natural colourants from other plants using different fabrics under the influence of radiations such as UV, microwave, ultrasonic and γ-irradiation.

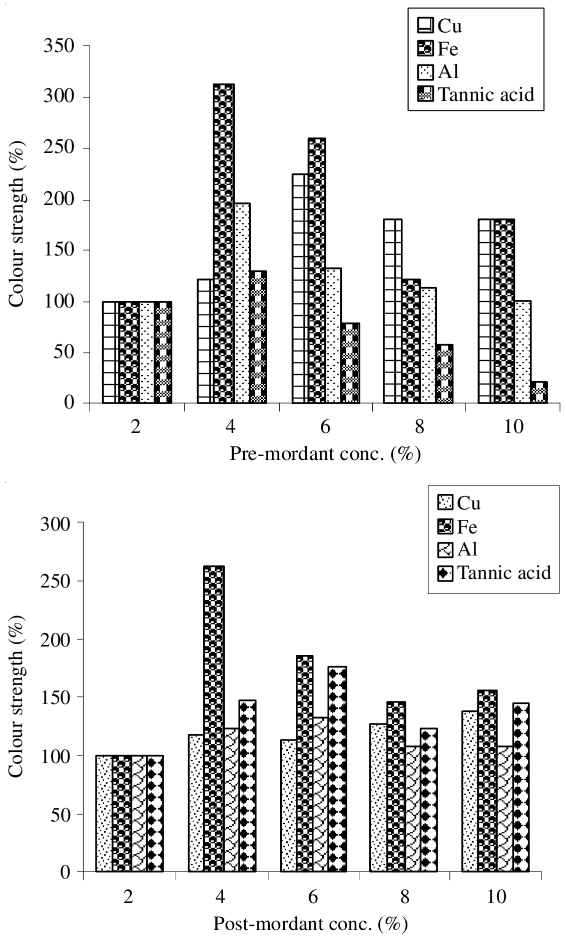



Fig. 7. Effect of pre-mordanting (a) and post mordanting (b) on the colour strength of irradiated cotton (RC) using aqueous extract of un-irradiated bark powder

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TABLE-1
EFFECT OF UV RADIATION ON THE COLOR FASTNESS PROPERTIES OF IRRADIATED FABRIC (RC) DYED AT OPTIMUM CONDITIONS USING AQUEOUS EXTRACT OF UN-IRRADIATED ACACIA POWDER (NRP)

| Optimum conditions | Light fastness | Wash fastness | Dry rubbing fastness | Wet rubbing fastness |
|---|---|---|---|---|
| Control (un-irradiated) | 3 | 3 | 3-4 | 3-4 |
| Exposure condition (RC, 90 min) | 4 | 4 | 4-5 | 4-5 |
| Temperature (50 ºC) | 3-4 | 3-4 | 4 | 4 |
| Time (55 min) | 3-4 | 3-4 | 4 | 4 |
| Dye bath pH (6) | 4 | 4 | 4 | 4 |
| Material to liquor ratio (M:L; 1:40) | 4 | 4 | 4 | 4 |
| Salt conc. (8 g/100 mL) | 4 | 4 | 4-5 | 4-5 |
| Pre-mordant conc. (4 % Fe) | 4 | 4 | 4-5 | 4-5 |
| Post-mordant conc. (4 % Fe) | 4 | 4 | 4-5 | 4-5 |

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