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An Investigation on Natural UV protective finishes on cotton fabrics

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Abstract

There is increasing interest in the many beneficial aspects of green tea and pomegranate to human such as anti-carcinogenic, antiaggregant, anti-allergic, anti-bacterial, anti-mutagenic and anti-oxidant activities. Besides these beneficial aspects, it has been reported that green tea & pomegranate



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Fig. 1- Structure of catechin and cellulose

X.X. Feng, L.L. et al. [2] have analyzed that the fabrics dyed with natural dyes had good ultraviolet protective properties. They could absorb about 80% of the ultraviolet rays. It was demonstrated that the UV-protective effect was strongly dependent on the absorption characteristics of natural dyes for UVR. Natural dyes such as Rheum and L. erythrorhizon had comparable UV-absorption performance to the common UV-absorber, benzophenone. Mordanting was done prior to dyeing (called pre-mordanting) to assist the adsorption of the dye and to promote good bonding of dye and fiber. The most commonly used mordant such as alum (potassium aluminum sulfate), chrome (potassium dichromate), iron (ferrous sulfate) and tin (stannous chloride). From their study it is finally concluded that, the effect of the mordant is to assist the adsorption of the dye and promote good bonding of dye and fiber as a bridge which helps to bond fiber and natural dyes at the molecular level. Ren-Cheng Tang & Sha-Sha Sun[3] examined that, the honey suckle extract can make a highly effective natural coating for clothing to meet a growing trend among consumers who are concerned about the risk of skin cancer and premature aging of the skin due to UV exposure. They said that natural UV-protection coatings can have advantages including production in a more sustainable fashion with less environmental impact and added that traditional and also they reported that wool coated with honeysuckle extract blocked UV rays much more effectively than untreated wool giving the fabric a high UV protection factor. The extract was durable and remained active on wool even after a long exposure to sunlight and laundering and gives the moderate UPF values. Sin-hee kim[4] reported that, Green tea Polyphenol decreased the penetration of UV and also decreased DNA photodamage and affected photo immunology. Conventionally, heavy metal ions such as copper, cadmium, iron, aluminum and tin were used in mordanting fabrics to enhance the natural dye uptake and the fastness. However, these heavy metals can cause an environmental problem and is a potential risk in skin contact and therefore, will not serve a proper role in this study. Therefore, chitosan was used in this study in mordanting cotton to increase the affinity of cotton fabric to green tea extract active moiety, i.e., catechin families. UV protective capabilities of a textile fabric are ranked with UPF value, which is the acronym for Ultraviolet Protection Factor. It's the ratio of the average effective ultraviolet radiation (UV-R) irradiance transmitted and calculated through air to the average effective ultraviolet radiation (UV-R) irradiance transmitted and calculated through fabric (ref. ASTM D6603). The higher the UPF value the greater the protection provided. Nattaya punrattanasin[5]

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investigated that, Green tea dyeing of cotton fabric via azoic combination method in order to improve ultraviolet protection properties without the application of polluting metal mordant. Three type of diazonium salt are prepared from three different primary aromatic amines and sub sequently, reacted with pretreated cotton fabric with coupling component or polyphenolic compound found in green tea expect to form an azoic dye in the cellulose matrix. The result showed that the strength of electron withdrawing group of the substituent in the primary aromatic amine, increase both color strength and ultraviolet protection factor of dyed fabric were dramatically increased. *Lisbeth*^[6] et al. investigated that, Pomegranate is a rich source of polyphenolics, which have been shown to exert anti-inflammatory, antioxidant and anticarcinogenic activity. This work investigated potential protective effects of a pomegranate fruit extract standardized to punicalagins against UV-A and UV-B induced damage in human skin fibroblast cells. Pomegranate extract (PE), in a range from 5 to 60 mg/l, was effective at protecting human skin fibroblasts from cell death following UV exposure. Higher polyphenolic concentrations (500-10000 mg/l) were needed to achieve a significant reduction in UV-induced reactive oxygen species levels and increased intracellular antioxidant capacity.

Material & Methodology:

100 % cotton fabric with plain weave has chosen for the present study. The fabric particulars are as follows: Warp count-36^s Ne, Weft count- 44^s Ne, EPI-105, PPI-60. Extraction of Green tea leaves & Pomegranate has done both in dry and wet state. Alum, Chitosan and Tartaric acid were used as mordents to improve natural dye uptake.

Table 1– Experimental plan for application of green tea and pomegranate on cotton fabric

Sl. No.	Extracts	State	Mordants
1	Untreated Sample		
2	Green tea	Fresh extract	Alum
3			Tartaric Acid
4			Chitosan

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5		Dry extract	Alum
6			Tartaric Acid
7			Chitosan
8	Pomegranate	Fresh extract	Alum
9			Tartaric Acid
10			Chitosan
11		Dry extract	Alum
12			Tartaric Acid
13			Chitosan

Treatment of cotton fabric with Green tea & Pomegranate:

Green tea extraction was done by two ways. In one method the fresh Green tea leaves were grind into paste using required amount of water in the ratio of 1:2. Then the paste is filtered and clear extract solution was prepared. In another method green tea extraction was done from dry green tea leaves using soxhlet apparatus followed by standards IS.10640.2011 [7]. Cotton fabrics were treated with 100 % green tea extract solution with M:L ratio of 1:30, to enhance the uptake of phenolic moiety, i.e. catechin mordanting was done with three different types of mordants namely Alum, Tartaric acid and Chitosan. Treatment was carried out in HTHP dyeing machine at a temperature of 80°C for a period of 50 minutes. After dyeing, dyeing batch was cooled down to the room temperature and the dyed materials were washed several times with water until no colorants came out and air-dried under the shade. The same method was followed for both extractions. Also same procedure was followed for the treatment of cotton with pomegranate.

Evaluation of UV Protection:

Transmittances of UV-A through the original cotton, Green tea dyed cotton and Pomegranate dyed cotton were measured using UV transmittance analyzer as per the AATCC183 standards [8]. The limits of the spectral range of ultraviolet radiation of UV-A given in the range of 315-400 nm. UV protection percentage was calculated from the following equation;

$$UPF = \frac{\sum E_{\lambda} \times S_{\lambda} \times \Delta\lambda}{\sum E_{\lambda} \times S_{\lambda} \times T_{\lambda} \times \Delta\lambda} \quad T(UV-A)_{AV} = \frac{\sum T_{\lambda} \times \Delta\lambda}{\sum \Delta\lambda}$$

Where,

E_{λ} = Relative erythemal spectral effectiveness

S_{λ} = solar spectral irradiance

T_{λ} = average spectral transmittance of the specimen

$\Delta\lambda$ = measured wavelength interval (nm)

Table 2- UPF Rating Scale

UPF Rating	Protection Category	% UV radiation Blocked
UPF 15 – 24	Good	93.3 – 95.9%
UPF 25 – 39	Very Good	96.0 – 97.4%
UPF 40 – 50+	Excellent	97.5 – 99+%

Result and Discussion

UV Protection Property of Green Tea & Pomegranate Dyed Cotton Fabrics

UV protection property of cotton fabrics treated with three different mordants using green tea extracts both fresh and dry leaves were measured. 1.

Untreated, 2. Fresh & Dry green tea extracts using alum, tartaric acid and chitosan as mordants. Table 2. Shows the standard UPF rating scale i.e. %UV

radiation Blocked based on their ratings [9]. Table 3., shows that UV protection, washing & rubbing fastness results for green tea and pomegranate dyed cotton fabric properties manifestly. In green tea fresh extract is showing significant effect on improvement of UV protection property. In the earlier studies the samples treated with green tea extract using chitosan as mordant shows that 93% of UV radiations were blocked by the treated sample. In this study the samples treated with green tea extract using alum and tartaric acid as Mordants have the increased protection up to 99%. So by this approach of replacing the mordant, the UPF rating could be positively uplifted from 93% to almost 99% which seems to be an appropriate eco friendly finish for the protection of UV rays.

The samples treated with fresh pomegranate extract using alum as mordant shows the UPF rating of 35.60 i.e. %UV radiation blocked in the range of 96.0 – 97.4%. Hence alum can be considered as the better mordant than the other two in case of pomegranate extract being used. More over its washing and rubbing fastness properties are considered to be average.

Table 3- UV protection, washing & rubbing fastness results for green tea and pomegranate dyed cotton fabrics

Sl. No.	Extracts	State	Mordants	UPF Value	Washing Fastness	Rubbing Fastness
1	Untreated Sample			9.66	–	–
2	Green tea	Fresh extract	Alum	54.08	3	3
3			Tartaric Acid	55.78	3	3
4			Chitosan	33.90	4	3
5		Dry extract	Alum	40.42	4	3
6			Tartaric Acid	16.08	4	3
7			Chitosan	14.71	5	3
8		Pomegranate	Fresh extract	Alum	35.60	3

9			Tartaric Acid	32.23	3	3
10			Chitosan	28.10	3	3
11		Dry extract	Alum	18.54	4	3
12			Tartaric Acid	13.76	4	3
13			Chitosan	12.59	4	3

Washing & Rubbing fastness Property of Green Tea & Pomegranate Dyed Cotton Fabrics

The washing & rubbing fastness result shows that there is no trend, and it shows average values in case of the samples treated with green tea and pomegranate extracts. Therefore the finished fabric can be used as apparels which do not require frequent washing and in better case it can be used as an outer covering of the garment which can block the hazardous UV rays from attacking the skin of the wearer.

Conclusion

UV protection property can be achieved using synthetic chemicals. But the difficulty of using chemicals is, it gives unpleasant feel to the wearer and more over it is not eco-friendly in nature. In order to reduce the impact on both human and environment, there is a need for using natural resources for the improvement of the %UV radiations blocked. There are various natural resources available among that green tea and pomegranate shown to be good UV protecting agents. In this investigation cotton fabrics treated with green tea extract using alum and tartaric acid as Mordants. The result shows that the increased protection up to 99% in case of green tea dyed cotton fabrics. So by this approach of replacing the mordant, the UPF rating could be positively uplifted from 93% to almost 99% which seems to be an appropriate eco friendly finish for the protection of UV rays. The samples treated with fresh pomegranate extract using alum as mordant shows the UPF rating of 35.60 i.e. %UV radiation blocked in the range of 96.0 – 97.4%. Since, the fastness

properties are average so, this kind of fabrics were best suited for outer covering of the garment which can block the hazardous UV rays from attacking the skin of the wearer.

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