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The Impact of Nanotechnologies on Developing The Printing of Natural Fabrics with Pomegranate Peel

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IN present work, different natural fabrics (cotton, wool and silk)were printed via pomegranate peel dye. The dye solution subjected to ultrasonic to reach the nano size.Two techniques of mordanting were used, (pre-mordanting and simultaneous mordanting);substrateswere mordanted prior to printing process using two ecofriendly mordants separately: Alum and tannic acid, other substrates were printed via paste incorporated with mordant for comparison. Pomegranate peel natural dye was studied to clarify the impact of nature of nano-size color particles on size, shape, and particle distribution of the natural dye with comparative studies of the K/S and over all fastness properties of printed samples.Results showed that the K/S values of nano samples are higher than original samples, irrespective of the nature of the fabric used and /or the concentration of the coloring matter. Nano-pomegranate peel dye could be used successfully instead of the original dye incorporated with Alum mordant irrespective of the fabric used. In addition,pre-mordanting technique acquired the higher K/S values than the simultaneous mordanting technique.There is a tendency of improvement of the perspiration fastness while keeping the washing and rubbing fastness unaltered after miniaturization of the pomegranate dye.

Keywords: Textile, Printing, Nanotechnology, Pomegranate peel, Natural fabrics, Eco-friendl***y.***

Introduction

Natural dyes are known for their use in coloring of food substrate, leather as well as natural fibers like wool, silk and cotton as major areas of application since pre-historic times.Recently, interest in the use of natural dyes has been growingrapidly due to the result of stringent environmental standards imposed by many countriesin response to toxic and allergic reactions associated with synthetic dyes.

Natural dyes have better bio-degradability and generally have higher compatibility with the environment. It is nontoxic, non-allergic to skin, non-carcinogenic, easily available and renewable.

Pomegranate (*Punica granatum* L.) is an ancient fruit that is widely consumed as fresh fruit and juice. The name pomegranate derives from medieval Latinpōmum "apple" and grānātum "seeded" [1].

The brown dry rind of the pomegranate especially that of the wild plants has been used as a dyestuff from the ancient times. Forbes writes: "In Mesopotamia the yellow dye was extracted as early as 2000 B.C. from pomegranate by grinding the rinds and extracting them with water. In Egypt it was in use from 1500 B.C. on words as finds in tombs proved; in Palestine it was used in dyes and inks.

Pomegranate (*Punica grantum*) belongs to the family Punicacea is native of Persia [2],but grows in most warm countries. The dried and powdered pomegranate rind has been used from ancient times as a natural coloring agent. The main coloring agent in the pomegranate peel is granatonine which is present in the alkaloid form N-methyl granatonine.

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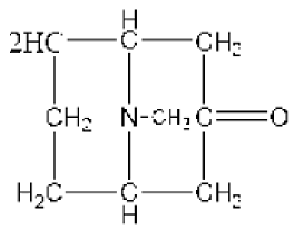

Scheme 1. Chemical structure of Punica –granatum.

Rinds of pomegranate (*Punica granatum*) fruits are rich in tannins and are used for mordanting purposes. A yellow dye is also present which can be used to dye wool, silk, and cotton with good fastness properties. It is also used along with turmeric for improving the light fastness of the dyed materials [3].

Several shortcomings are encountered with the use of conventional natural colorationin textile dyeing and printing are color yield, complex-ability of dyeing process, reproducibility results, limited shades, blending problems and inadequate fastness properties; poor wet rubbing fastness, light fastness, poor shades and harsh hand resulting from regular size dye particles and nature of the binder used [4].

To overcome these problems, improving the dispersion of the natural dye becomes necessary. Modification of natural dye morphology can decrease the average of dye particle's diameter to 100-200 nm and, in so doing; the natural dye dispersion acquires greater stability and color strength approaching that of dyes [5].

Nanotechnology is the science and technology of designing, constructing and creating of novel nano-scale structure, 1nm to 100 nm in size, with huger quality, novel performance properties, along with fewer defects compared with those of the bulk material [6].

It can provide high durability to fabrics, because nanoparticles have a large surface area-to-volume ratio and high surface energy, thus presenting better affinity for fabrics and leading to an increase in durability of the function [7].

When matter is reduced in size, it changes its characteristics, such as color and interaction with other matter, *i.e.* chemical activity. The change in characteristicsis caused by the change of the electronic properties. By particle size reduction, the surface area of the material is increased. Due to this, a higher percentage of atoms can interact with other matter.

The present work is undertaken with a view to harness nanotechnology as one of the most important frontier sciences for development of printing natural fabrics using the most eco-friendly dyes namely Pomegranate peel. This was done to clarify the import of nature of nano-size color particles on size, shape and particles distribution of the natural dyes with comparative studies of the K/S and overall fastness properties. Role of miniaturization of the used Pomegranate peel on its printability of cotton, wool and silk in presence and absence of mordants will be investigated.

Experimental

Materials

Fabrics

- Cotton fabric:Mill desized, bleached and mercerized cotton fabrics 165 g / m^2 produced by Misr/Helwan for Spinning and Weaving Company, Helwan, Egypt.
- Wool fabrics:Mill scoured 100% wool fabric supplied by Misr Company. for spinning and weaving (Mehalla El-Kubra) 210 g / m^2 , Mehalla, Egypt.
- Silk fabrics:Mill scoured natural Silk fabric of plain weave 60 g / m^2 supplied by El-Khateib Company. Souhag, Upper Egypt.

Dyestuff: Natural Coloring substance Pomegranate peel [which have been purchased from local market] was extracted according to the procedure described latter.

Thickening agents: Commercial synthetic thickening agent, namely Printofix thickener MTB 01 EG liq manufactured by CLARIANT companywas also used.

Mordants: Alum [hydrated double sulfate of potassium hydrogen sulfate ($KAl(SO_4)_2.12H_2O$], and tannic Acid ($C_{76}H_{52}O_{46}$).

Methods

Extracting of natural coloring matter

100 g. Pomegranate peel dry powder were added to 1000 ml. water and subjected to boiling under reflux for 30 min. The mixture was left to cool at room temperature and then filtrated off. The filtrated solution was concentrated using a laboratory Rotavapour.

Preparation of nano particles of pomegranate peel natural dye using ultrasonic stirrer

Different amount "X" (3, 5, or 7gm) of filtrated solution of Pomegranate peel were suspended in 100ml distilled water under stirring then the solution were set to motion in the Ultrasonic stirrer (The probe is turned to resonate at specific frequency, 20 KHZ $\pm$ 100 HZ). The Ultrasonic stirrer was operated for 60 min at ca 80˚C to reach the nano-size.

Preparation of the printing pastes

The extracted Pomegranate peel color was subjected to minimization using Ultrasonic stirrer as previously mentioned. Different printing pastes containing natural Pomegranate peel color before and after minimization were prepared according to the following recipes:

Dye suspension original or nano sample *	20 g
Urea	2.5g
Thickener	2.5g
Binder	5g
Sodium dihydrogen phosphate dehydrate	0.5g
Mordant **	X
Distilled water	Y
Total	100

* 20g was taken from each dyeing solution (original or nano-size) containing Pomegranate peel color at a concentration of 3, 5, or 7 g dye in 100 ml water.

** The mordant was incorporated direct in the printing paste.

Mordanting of natural fabrics

Mordanting of the natural fabrics (cotton, wool or silk) were conducted using two different techniques; either pre-mordanting or simultaneous, *i.e.* added directly to the printing were used.

Printing techniques

The aforementioned three different fabrics, *i.e.* wool, cotton, or silk were printed with the prepared printing paste via screen, *i.e.* screen printing technique.

After printing and dyeing the printed goods were subjected to steaming at 115˚C for 10 min for silk, and for 20 min for both cotton and wool followed by thoroughly washing and finally air-dried. At the end, the fabrics were assessed for K/S and overall fastness properties.

Testing, analysis and measurements

Transmission electronic microscopy (TEM) [8]

Particle shape and size were obtained using a JEOLJEM 1200. Specimens for TEM measurements were prepared by dissolving a drop of colloid solution on a 400 mesh copper grid coated by an amorphous carbon film and evaporating the solvent in air at room temperature. The average diameter of the natural dye nanoparticles was determined from the diameter of 100 nanoparticles found in several arbitrarily chosen areas in enlarged microphotographs.

Color strength & fastness

The color strength (K/S) of the samples was evaluated by light reflectance technique using Shimadzu UV/Visible spectrophotometer [9].

The color strength expressed as K/S value was assessed by applying the Kubelka equation as follows:

$$K/S = \frac{(1-R)^2}{2R} - \frac{(1-R_o)^2}{2R_o}$$

Where:

R = Decimal fraction of the reflectance of the dyed fabric.

R_o = Decimal fraction of the reflectance of the un-dyed.

K = Absorption coefficient.

S = Scattering coefficient.

In addition, the color overall fastness properties: *i.e.* to washing, perspiration or rubbing fastness were assessedaccording to standard methods [10]. The color fastness to rubbing was determined according the AATCC test method 8-977; The color fastness to washing determined according to the AATCC test method 36-1972. While on the perspiration tests the effect on the color of the test specimen was expressed and defined by reference to the gray scale for color change.

Results and Discussion

Dependence of the size of pomegranate peel particles on its concentration

To start with TEM investigation of the particles size of the pomegranate peel color, Fig. 1- 3 show the TEM micrographs of pomegranate peel at original size, *i.e.* before subjecting to ultrasonic stirring at a concentration of 3,5 and 7%. Figures 4-6 represent the particle size after subjecting to ultrasonic stirring for 60 min, at Ca 80 ˚C.

A close examination of Fig. 1 which represent the TEM at a concentration of a concentration of 3% before subjecting to ultrasonic stirring signifies as average particle size of 323.3 nm. Indeed this average covers a wide distribution of size particles ranging from 190 to 530 nm. While Figure4 represents TEM micrograph of the same sample after subjecting to ultrasonic technique. As is obvious the average of Pomegranate peel particle size of 29.4. Indeed this average covers the particle size ranges from 16.7 nm to 47.5 nm. It is further noted that the nanoparticles exhibit a perfectly uniform spherical shape with very broad particle size distribution and with little or no evidence of aggregation / agglomeration. Figures 2,3 and figures 5.6 represent the TEM before and after miniaturization at concentrations of 5 and 7 %, respectively.

Although the particle size is reduced as compared with their mates before ultrasound stirring, yet the particles display some aggregation and agglomeration. Most probably, breaking down the dye particles increases significantly their surface area allows for association and coagulation of the particles through Van der Waals and hydrophobic -hydrophobic interactions.

While Table 1 summarizes the effect of concentration of pomegranate peel on the particle size before and after nanofication.

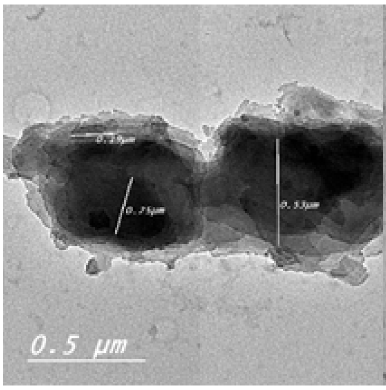

Fig. 1. 3% original dye .

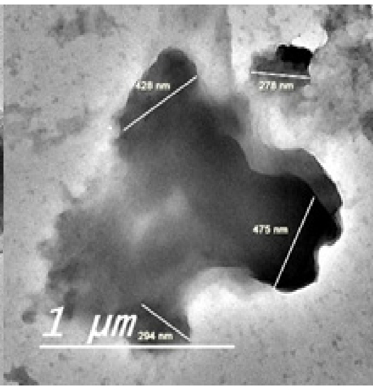

Fig 2. 5% original dye .

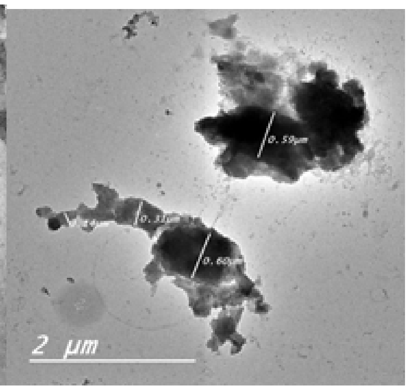

Fig .3.7% original dye.

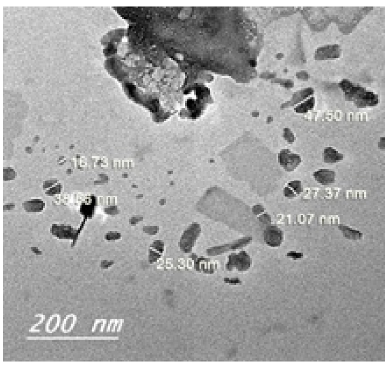

Fig .4. 3% nano dye .

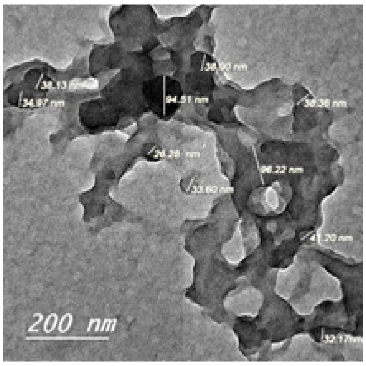

Fig.5. 5% nano dye.

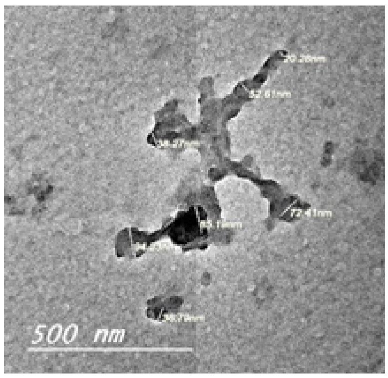

Fig.6. 7% nano dye.

TABLE 1. Comparison between Pomegranate peel particle size before and after miniaturization using ultrasound based technique.

Dye	Con. of dye	Original size			Nano size			Percent decrease
		Average size of dye particle	Max. size of dye particle	Min. size of dye particle	Average size of dye particle	Max. size of dye particle	Min. size of dye particle	
pomegranate peel	3%	323.3	530	190	29.4	47.5	16.7	90.91%
	5%	368	475	278	47.5	96.2	26.3	87.09%
	7%	410	600	140	57.1	94.2	20.3	86.07%

It is evident that the average particle size of the dye before ultrasonic drops outstandingly after ultra-sonification. The average drops from 323.3 nm to 29.4nm, from 368 nm to 47.5nm and from 410 nm to 57.1 nm upon the dye concentration used. The decrease percentage of miniaturization of particle size are (90.91 %, 87.09 %, 86.07 %) at dye concentrations of (3, 5, and 7%) respectively. It is logical that the disintegrating actions caused by mechanical energy transfer from the stirring tool to dye particles together with the thermal energy of the miniaturizing medium and the fast collision and abrasive actions of the dye particles on themselves. The result presented by relatively larger nano-sized dye particles observed with high concentration as compared with other concentration suggests faster aggregation / agglomeration of the nano-sized dye particles.

Effect of miniaturization of Pomegranate peel color to nano-sized on its printability on natural fabrics

To investigate the effect of decreasing the particle size of Pomegranate peel to the nano-form on its printability on natural fabrics, printing pastes containing the aforementioned three concentrations before and after miniaturization were prepared in presence or absence of mordants. The prepared pastes were applied to print the aforementioned three natural fabrics according to the procedure described in the experimental section. Given below the results obtained along with the appropriate discussion.

Comparison between original and nano-size: (In absence of mordant)

Table 2 represents the data of K/S obtained using different concentrations of Pomegranate peel before and after militarization

TABLE 2. Effect of miniaturization of Pomegranate peel color to nano-sized on K/S in absence of mordant.

Fabric	Dye Con. %	K/S Without mordant		
		In original form	In nano Form	% increase in K/S
On Wool	3	2.70	3.59	32.96%
	5	3.02	3.56	17.88%
	7	3.31	4.27	29.00%
On Silk	3	2.27	2.71	19.38%
	5	2.09	2.69	28.71%
	7	2.92	3.02	3.42%
On Cotton	3	1.95	2.51	28.72%
	5	2.01	2.87	42.79%
	7	2.74	2.92	6.57%

It is clear from the data of Table 2 that the K/S is oppositely related to the size of the nano particles. Decreasing the particle size is accompanied by substantial enhancement in color strength.

The increase in K/S on decreasing the particle size to the nano-scale may be due to the virtue of their small nano-scale size and large surface area which make the particle defuse faster in the interior of the printed fabrics and distributed themselves on the fabric surface during printing. In so doing, they produce prints with strong color shade and, therefore, higher color strength compared with the original particles which acquire relatively larger size.It is clear from the data, Irrespective of the fabric used, the K/S values of nano samples are higher than original samples.

Proteinic fabrics, *i.e.* wool and silk acquire high affinity for natural colors than cellulosic fiber i.e. cotton. It has been reported [11, 12] that natural dyes are high molecular weight compounds containing phenolic hydroxyl groups which enable them to form effective cross-links between proteins such as wool and silk, where they form three types of bonds namely. (a) Hydrogen bond: which is formed between phenolic hydroxyl groups of natural dye and the free amino and amides groups of the proteins. (b) Ionic bond: it is formed between suitable charged anionic groups of the natural dye and cationic groups on the protein. (c) Covalent bond: it is formed by interaction of any quinone or semi quinone group present in natural dye with any suitable reactive groups in the protein.

However in case of cellulosic, exemplified by cotton, the natural dye could form only two types of bonds as follows: (a) Hydrogen bond: which is formed between phenolic hydroxyl groups of natural dye and the hydroxyl groups of cellulose. (b) Covalent bond which may be formed by the interaction of quinone or semi quinone groups present in natural dye with suitable functional groups in the cellulose.

In addition, as the concentration of the Pomegranate peel dye increases, the K/S value increases irrespective of the particle form (either original or nano).

Comparison between original and nano-size of pomegranate peel dye in presence of pre-mordant:

Table 3 represents the data of K/S on using pomegranate peel in original and nano form on printing of pre-mordanted samples (wool, silk or cotton) with Alum / or Tannic Acid mordant.

Irrespective of the fabric used; the K/S values of nano samples are higher than original samples This phenomenon holds true in order to a matter is reduced in size, it changes its characteristics, such as color and interaction with other matter.

Comparison between nano-dye and original dye with mordant

To investigate the possibility of using nano-dye instead of using mordants with original dye. Different samples (wool, silk or cotton) were printed with different mordants (alum or tannic acid) incorporated with original Pomegranate peel dye, while other samples printedwith only nano-pomegranate peel dye for comparison.

TABLE 3. Effect of miniaturization of pomegranate color to nano-sized on K/S in presence of pre-mordant.

Fabric	Dye Con. %	K/S With Alum mordant		K/S With Tannic Acid mordant	
		In original form	In nano Form	In original form	In nano Form
On Wool	3	2.95	3.87	3.61	4.24
	5	3.17	4.15	3.90	4.59
	7	3.66	3.71	4.44	4.69
On Silk	3	2.12	2.27	4.90	5.90
	5	1.82	2.48	5.15	5.77
	7	2.59	2.80	5.83	5.96
On Cotton	3	1.59	1.90	2.36	3.32
	5	1.94	2.93	2.31	3.02
	7	2.46	2.54	2.91	3.77

TABLE 4. Comparison between printing dye in nano-form, and dye in original form incorporate with mordant.

Nature of fabric	Dye conc. %	K/S of Nano dye	K/S of original dye incorporate with mordant	
			Alum	Tannic acid
Wool	3%	3.59	2.46	3.14
	5%	3.56	2.31	3.15
	7%	4.27	2.52	2.88
Silk	3%	2.71	2.02	2.73
	5%	2.69	1.73	2.90
	7%	3.02	2.26	2.58
Cotton	3%	2.51	1.53	2.27
	5%	2.87	1.45	2.45
	7%	2.92	1.82	2.23

It is clear from the data of Table 4 that; the K/S values of nano- dye samples are higher than the original dye incorporate with alum mordant. Therefore, Nano-pomegranate peel dye could be used successfully instead of the original dye incorporated with Alum mordant irrespective of the fabric used. Besides that, Tannic acid mordant could be substituted with using the nano-dye only on wool and cotton fabrics.

Comparison between original-dye, nano-dye, and nano-dye incorporated with nano-tannic acid at dye concentration 5%

It is clear from Fig. 7 that, irrespective of the fabric used, the nano-dye incorporate with nano- Tannic acid mordant acquired the highest K/S values followed by, the dye in nano-form, while the dye in original form acquired the lowest values.

Effect of mordanting technique on K/S of printing Pomegranate peel colorant in original form

To study techniques of mordanting (pre-mordanting and simultaneous mordanting) of Alum/Tannic acid mordants and their effects on printing Pomegranate peel in original form, on wool, silk or cotton samples, and compared with non-mordanted samples, The K/S values were remarked as shown in Table 5.

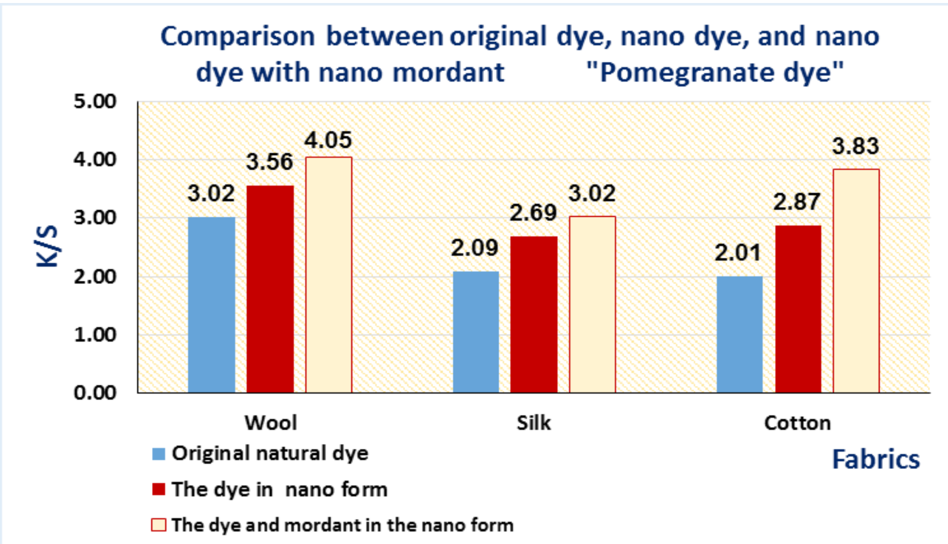

Fig.7.Comparison between K/S of Pomegranate peel dye in original and nano- size and nano-dye incorporate with nano-tannic acid.

TABLE 5. Comparison between using pre-mordanting and simultaneous mordanting on K/S of printed original-form.

Nature of fabric	Dye conc. %	K/S of Samples without mordant	K/S of Samples with Alum mordant		K/S of Samples with Tannic acid mordant	
			I	II	I	II
Wool	3%	2.70	2.95	2.46	3.61	3.14
	5%	3.02	3.17	2.31	3.90	3.15
	7%	3.31	3.66	2.52	4.44	2.88
Silk	3%	2.27	2.12	2.02	4.90	2.73
	5%	2.09	1.82	1.73	5.15	2.90
	7%	2.92	2.59	2.26	5.83	2.58
Cotton	3%	1.95	1.59	1.53	2.36	2.27
	5%	2.01	1.94	1.45	2.31	2.45
	7%	2.74	2.46	1.82	2.91	2.23

(I): K/S of the mordant was applied via padding technique “Pre-mordanting”.

(II): K/S of the mordant was incorporated direct in the printing paste “simultaneous”.

- On using Alum mordant: pre-mordanting technique acquired the higher K/S values than the simultaneous mordanting technique.The highest K/S values was obtained on using 7% of Pomegranate peel dye, irrespective of the fabric used or the applied technique.
- On using Tannic acid mordant:on silk fabricsthe pre-mordant technique has obviously highest K/S of the printed samples than the un-mordanted samples or the simultaneous samples.

Irrespective of the fabric used, In case of the pre-mordanted, by increasing the dye concentrations, the K/S values increase. The highest K/S value of pre-mordanted technique at 7% dye concentration.While the highest K/S value of simultaneous technique at 5% dye concentration.

Comparison between using pre-mordanting and simultaneous mordanting on K/S of printed nano-form

To study techniques of mordanting of Alum/ Tannic acid mordants and their effects on printing Pomegranate peel in nano form, The K/S values were remarked as shown in Table 6.

TABLE 6. Comparison between using pre-mordanting and simultaneous mordanting on K/S of printed nano-form.

Nature of fabric	Dye conc. %	K/S of Samples without mordant	K/S of Samples with Alum mordant		K/S of Samples with Tannic acid mordant	
			I	II	I	II
Wool	3%	3.59	3.87	2.50	4.24	3.97
	5%	3.56	4.15	2.44	4.59	3.80
	7%	4.27	3.71	2.69	4.69	3.59
Silk	3%	2.71	2.59	2.13	5.90	3.08
	5%	2.69	2.48	2.12	5.77	3.38
	7%	3.02	2.80	2.18	5.96	3.04
Cotton	3%	2.51	1.90	1.79	3.23	3.12
	5%	2.87	2.93	1.81	3.02	3.24
	7%	2.92	2.54	1.82	3.77	2.76

(I): K/S of the mordant was applied via padding technique “Pre-mordanting”.

(II): K/S of the mordant was incorporated direct in the printing paste “simultaneous”.

On using Alum mordant:K/S values of the pre-mordanting acquired the higher values than the simultaneous mordanting irrespective of the fabric used or dye concentrations. The same trend was applied on using tannic acid with proteinic fabrics (wool – silk).

Effect of miniaturization on fastness properties of Pomegranate peel printed samples

The color fastness properties of the natural fabrics printed with Pomegranate peel in presences of different mordants (Alum or Tannic acid) or without mordant were measured. Table 7 represents the data for the K/S values and the color fastness to washing, to rubbing, and to perspiration for deferent fabrics (Wool-Silk-Cotton) printed with Pomegranate peel before and after miniaturization.

TABLE 7. Color strength (K/S) and overall fastness properties of wool, silk and cotton printed with Pomegranate peel before and after miniaturization.

On wool

a) Before miniaturization

Samples before miniaturization				Washing fastness		Rubbing fastness		Perspiration			
								Acidic		Alkaline	
Printed fabric	Mordant	Dye conc. gm / 100 ml H_2O	K/S of Printed fabric	Alt.	St.	Dry	Wet	Alt.	St.	Alt.	St.
Wool	Without mordant	3	2.71	4-5	4	4-5	3-4	4	4	4	4
		5	3.02	4-5	4	4	3-4	4	4	4	4
		7	3.31	4-5	4	4-5	3-4	4	4	4	4
	With Alum	3	2.95	4-5	4	4	4	3-4	3-4	3-4	3-4
		5	3.17	4-5	4	4	4	3-4	3	3-4	3-4
		7	3.66	4-5	3-4	4	3-4	4	3-4	3-4	3-4
	With Tannic acid	3	3.61	4-5	4	4-5	3-4	3-4	3-4	3-4	3
		5	3.90	4-5	4	4-5	3-4	3-4	3-4	3-4	3
		7	4.44	4-5	3-4	4	2-3	3-4	3-4	3-4	3

Alt. : Alteration St.: Staining

b) After miniaturization

Samples After miniaturization				Washing fastness		Rubbing fastness		Perspiration			
								Acidic		Alkaline	
Printed fabric	Mordant	Dye conc. gm / 100 ml H_2O	K/S of Printed fabric	Alt.	St.	Dry	Wet	Alt.	St.	Alt.	St.
Wool	Without mordant	3	3.59	4-5	4	4-5	4	4	4	4	4
		5	3.56	4-5	4-5	4-5	4	4-5	4	4-5	4
		7	4.27	4-5	4	4-5	4-5	4-5	4-5	4-5	4-5
	With Alum	3	3.87	4-5	4	4-5	4	4	3-4	3-4	3-4
		5	4.15	4-5	4	4-5	3-4	4-5	4	4	4
		7	3.71	4-5	4	4-5	3-4	4-5	4	4	4
	With Tannic acid	3	4.24	4-5	4-5	4	3-4	4	3-4	3-4	3
		5	4.59	4-5	4-5	4	3-4	4	3-4	3-4	3-4
		7	4.69	4-5	4	4-5	3-4	4	3-4	3-4	3-4

Alt. : Alteration St.: Staining

On silk

a) Before miniaturization

Samples before miniaturization				Washing fastness		Rubbing fastness		Perspiration			
								Acidic		Alkaline	
Printed fabric	**Mordant**	**Dye conc. gm / 100 ml H_2O**	**K/S of Printed fabric**	**Alt.**	**St.**	**Dry**	**Wet**	**Alt.**	**St.**	**Alt.**	**St.**
Silk	Without mordant	3	2.27	4-5	4-5	4-5	3-4	4	4	4	4
		5	2.09	4-5	4-5	4	3-4	4	4	4	4
		7	2.92	4-5	4-5	4	3-4	4	4	4-5	4
	With Alum	3	2.12	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		5	1.82	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		7	2.59	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	With Tannic acid	3	4.90	4-5	4-5	4-5	3-4	4	4	4	4
		5	5.15	4-5	4	4-5	3-4	4-5	4	4	4
		7	5.83	4-5	4	3-4	3-4	4-5	4	4-5	4

Alt. : Alteration St.: Staining

b) After miniaturization

Samples After miniaturization				Washing fastness		Rubbing fastness		Perspiration			
								Acidic		Alkaline	
Printed fabric	**Mordant**	**Dye conc. gm / 100 ml H_2O**	**K/S of Printed fabric**	**Alt.**	**St.**	**Dry**	**Wet**	**Alt.**	**St.**	**Alt.**	**St.**
Silk	Without mordant	3	2.71	4-5	4-5	4-5	3-4	4-5	4	4-5	4
		5	2.69	4-5	4-5	4	3-4	4-5	4	4-5	4
		7	3.02	4-5	4-5	4-5	4-5	4-5	4	4-5	4
	With Alum	3	2.27	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5
		5	2.48	4-5	4-5	4-5	3-4	4-5	4-5	4-5	4-5
		7	2.80	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	With Tannic acid	3	5.90	4-5	4-5	4-5	4	4-5	4	4-5	4-5
		5	5.77	4-5	4-5	4-5	4	4-5	4	4-5	4-5
		7	5.96	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5

Alt. : Alteration St.: Staining

On Cotton

a) Before miniaturization

Samples before miniaturization				Washing fastness		Rubbing fastness		Perspiration			
								Acidic		Alkaline	
Printed fabric	**Mordant**	**Dye conc. gm / 100 ml H_2O**	**K/S of Printed fabric**	**Alt.**	**St.**	**Dry**	**Wet**	**Alt.**	**St.**	**Alt.**	**St.**
Cotton	Without mordant	3	1.95	4-5	4-5	4-5	3-4	4	4	4	4
		5	2.01	4-5	4-5	4-5	4	4	4	4	4
		7	2.74	4-5	4-5	4-5	3-4	4	4	4	4
	With Alum	3	1.59	4-5	4-5	4-5	4-5	3-4	3-4	4	3-4
		5	1.94	4-5	4-5	4-5	4	4	3-4	4	3-4
		7	2.46	4-5	4-5	4-5	3-4	4	3-4	4	3-4
	With Tannic acid	3	2.36	4-5	4	4-5	4-5	3	3-4	3-4	3
		5	2.31	4-5	4	4-5	4-5	3-4	3-4	3-4	3
		7	2.91	4-5	4	4-5	4-5	3-4	3-4	3-4	3-4

Alt. : Alteration St.: Staining

b) After miniaturization

Samples After miniaturization				Washing fastness		Rubbing fastness		Perspiration			
								Acidic		Alkaline	
Printed fabric	**Mordant**	**Dye conc. gm / 100 ml H_2O**	**K/S of Printed fabric**	**Alt.**	**St.**	**Dry**	**Wet**	**Alt.**	**St.**	**Alt.**	**St.**
Cotton	Without mordant	3	2.51	4-5	4-5	4-5	4	4-5	4-5	4	4
		5	2.87	4-5	4-5	4-5	4	4-5	4-5	4-5	4
		7	2.92	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4
	With Alum	3	1.90	4-5	4-5	4-5	4-5	4	4	4	4
		5	2.93	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4
		7	2.54	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	With Tannic acid	3	3.23	4-5	4-5	4-5	4	4	4	4	4
		5	3.02	4-5	4-5	4-5	3-4	4	4	4	4
		7	3.77	4-5	4-5	4-5	3-4	4	4	4	4

Alt.: Alteration St.: Staining

The first glance at the result of Table 7 would imply that the color strength (K/S) for the printed samples before the miniaturization is much lower than after miniaturization. Printability of the nano-dye particles would be governed by several factors of which nature of the substrate to be printed comes to play an important role. For example on wool fabric:Before miniaturization,The table data shows that washing properties ranging from very good to excellent whereas the rubbing and perspiration ranging from good to very good. While after the miniaturization: the overall properties ranging from very good to excellent.

With respect to fastness properties, there is a tendency of improvement of the perspiration fastness while keeping the washing and rubbing fastness unaltered after miniaturization of the pomegranate peel dye.

Conclusions

Nanoscale pomegranate peel natural dye with particle size less than 100 nm were successfully prepared by using ultrasonic starrier in order to accelerate fibers' chemical reactivity.

Pomegranate peel natural dye is successfully used in printing the substrate, *i.e.* huge color intensity developments, and deeper hues are achieved comparing printing using the nanoparticledye with the originaldye.

Nature of the dye used determines the size of dye particle, particle size distribution and shape of the particles; this is true before and after miniaturization.

Irrespective of the fabric used, the K/S values of nano samples are higher than original samples, lead to use small amount of nano-dye instead of large amount of original dye with the same quality.

In absence of mordant, the highest K/S was obtained at 7% of original dye concentration in both original and nano-form.

Using two eco-friendly mordants separately [tannic acid or potassium aluminum sulphate (alum)] to increase the affinity as well as dye fixation onto fibers via formation of complex bonds. With two techniques (pre-mordanting and simultaneous mordanting for comparison.

Nano-pomegranate peel dye could be used successfully instead of the original dye incorporated with Alum mordant irrespective of the fabric used. Besides that, Tannic acid mordant could be substituted with using the nano-dye only on wool and cotton fabrics.

On using alum mordant, pre-mordanting technique acquired the higher K/S values than the simultaneous mordanting technique.

There is a tendency of improvement of the perspiration fastness while keeping the washing and rubbing fastness unaltered after miniaturization of the pomegranate dye

By using nano-dye there is improvement of harsh handle of printed samples.

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تأثير النانوتكنولوجى على تطوير طباعة الألياف الطبيعية بقشر الرمان

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تم فى هذا البحث تحضير صبغة طبيعية مستخرجة من قشر الرمان و تصغيرها فى حجم النانو ليصل حجم جزيئاتها الى اقل من ١٠٠ نانومتر قد تم تحضير تلك الصبغة بإستخدام جهاز تقليب بالموجات فوق الصوتية ، وذلك بهدف تصغير حجم جزيئات الصبغة و جعلها أسرع لأختراق الخامات النسجية و تلوينها.

و قد تم إستخدام الصبغة المحضرة للطباعة بها بنجاح و تم الحصول على درجات لونية متطورة بالاضافة الى عمق لونى عالى بالمقارنة بالحجم الطبيعى للصبغة بدون تصغير.

تعرضت الصبغة الطبيعية المحضرة لقياس الحجم الجزيئى للصبغة المقارنة بين قبل و بعد المعالجة و تحضيرها للطباعة بها على خامات نسجية مختلفة من القطن و الصوف و الحرير. بغض النظر عن نوع الخامة المستخدمة للطباعة لقد وجد ان الدرجات اللونية المحققة بالصبغة المحضرة أعلى بكثير من مثيلتها الغير مصغرة. و قد تم دراسة دور التركيزات المختلفة للصبغة قبل و بعد التصغير على شدة اللون المطبوعات، و قد وجد ان مع التركيزات المختلفة للصبغة المحضرة قد تم الحصول من تركيز ٧٪ على اعلى شدة لون للمطبوعات.

و لقد لوحظ أيضاً أن استخدام نوعين من الموردنتالامنين بيئيا وهما حمض التانيك و سلفات اللومنيوم (الالوم) يزيد من قدرة الصبغة و كذلك ثبات الصبغات و أرتباطها بالخامة و ذلك فى جميع الحالات محل الدراسة بالاضافة الى تحقيق درجات ثبات للغسيل و العرق و الاحتكاك جيدة جدا و بالاخص بالصبغات المحضرة فى حجم النانو.