American Journal of Polymer Science and Engineering
http://www.ivyunion.org/index.php/ajpse/

Research Article

Improving the Fastness Properties of Cotton Fabric through the Implementation of Different Mordanting Agents Dyed with Natural Dye Extracted from Marigold

Mazharul Islam[1], K. M. Faridul Hasan[1*], Hridam Deb[1],
Md Faisal Ashik[2], Weilin Xu[1]

[1]School of Textile Science and Engineering, Wuhan Textile University, Wuhan, China
[2]School Chemistry and Chemical Engineering, Wuhan Textile University, Wuhan, China

Abstract
Extraction of natural dyes for the coloration of Textile substrate is one the most important research area to the researchers. It is tried to extract the natural dyes from marigold flower through using the different kinds of mordanting agents. In this research, a particular source is used for dyes extraction. Before the extraction Patel of the marigold flower was extracted and dried on sunlight, subsequently dried in room temperature due to preserve the natural colorant. The natural dyes were extracted by boiling the above substrates in water without any chemicals. As mordant, Potash Alum [$K_2Al_2(SO_4)_3.24H_2O$], Ferrous Sulphate($FeSO_4$),Copper Sulphate ($CuSO_4$),Nickel (II) Sulphate ($NiSO_4$),Potassium Dichromate ($K_2Cr_2O_7$),Stannous Chloride($SnCl_2$) were used. The mordanting procedures were followed same for all the experiments. The treatment runtime was 60 minute at 100^oC. After mordanting each sample fabric was kept for 24 hours for conditioning and then the dyeing was done. But as there is no particular dyeing method for natural dyeing so it is followed some trial and some convenient methods were made after trial for several times. Mordanted samples were wet out in cold water before dyeing. During dyeing some salt or soda was added to observe the effects through the Runtime 60 minutes at 60^oC. After dyeing samples were cold rinsed and soaping was done and dried with hot air dryer. Finally the color fastness like Color fastness to wash, Color fastness to perspiration/saliva, Color fastness to water, Color fastness to rubbing and Color fastness to light were checked and found satisfactory result.

Keywords: Natural Dyes; Mordant; Extraction; Dyeing; Fastness
Received: July 17, 2016; **Accepted**: August 12, 2016; **Published**: September 12, 2016
Competing Interests: The authors have declared that no competing interests exist.

***Correspondence to:** K. M. Faridul Hasan, School of Textile Science and Engineering, Wuhan Textile University, Wuhan, China
E-mail: farid_textile@yahoo.com

1. Introduction

1.1. Natural Dyes

Nature provides rainbow colors that show up in everyday lives. The art of making dyes from plants dates back for centuries. When settlers first came to America, it was necessary to import their favorite dyes and fabrics. After years of experimenting they learned to use plants for making other suitable colors. Those colors and the plants they are made from survive still now. There are many flowers, berries, bark, leaves, nuts and roots that will yield dyes [1]. These metallic mordants after combining with dye in the fibre, it forms an insoluble precipitate or flake and thus both the dye and mordant get fixed to become wash fast to a reasonable level [2, 3].

Natural dyes obtained from renewable resources of nature, such as plant and animal, although natural dyes from minerals of the earth are also known. Colouring matter derived from different organs of a plant, such as root, leaf, bark, trunk or fruit are known as vegetable dyes; while the colouring matter obtained from the animal kingdom such as lac, cochineal and kermes are known as animal dyes [4]. Colouring matters obtained from various inorganic metal ores and metal salts are known as mineral dyes. Natural dyes find application chiefly for colouration of food, drugs, cosmetics and textile. Some quantities of dyes are also used for colouration of paper, leather, shoe-polish, candle, wood etc. Use of natural dyes for colouration of textile is practiced since early days. After the synthesis of Mauveine by William Henry Perkin and its subsequent commercialization, the use of natural dyes receded and the position continued to be much the same until in the recent past growing consciousness about environmental preservation and control of pollution and conventional wisdom and belief regarding environment friendliness of natural dyes have renewed interest for use of natural dyes for the colouration of textile [5, 6].

1.2. Marigold Flowers

The Marigold flowers (Fig. 1) bloom from the beginning of summer up to autumn. The flowers contain flavonol - quercetagetol which is a derivative of quercetol. It is accompanied by 2 of its glucosides and luteine (a carotenoid). It also contains patulutol and some ellegic acid which act as a mordant. The flower contains several pigments which appear to vary with the source of material. This flower contains mainly two classes of pigments:-

a) Flavonoids,

b) Carotenoids.

Fig. 1 Marigold flower.

Flavonol is major subgroup of flavonoids. It is present in woody angiosperms and is soluble in

water. Xanthophyll is also present in flower and it is insoluble in water, but soluble in fats and in fat solvents. Quercetagetin have been isolated from Indian types, and kaempferitrin and helenien from Rumanian varities [3, 7].

1.3. Cotton Fiber

Cotton is the main cellulosic fiber. Throughout the world there are many species of cotton produced from their own unique properties. Species variations can include staple length, strength, elongation at break, uniformity ratio, fineness, color and trash content. The earliest evidence of using cotton is from India and the date assigned to this fabric is 3000 B.C. Cotton is produced in china, Egypt, South America etc. the large-scale cotton cultivation in Northern America began in the 16th century with the arrival of colonists to southern parts of today's United States [8, 9].

1.3.1. Chemical and Physical structure of cotton

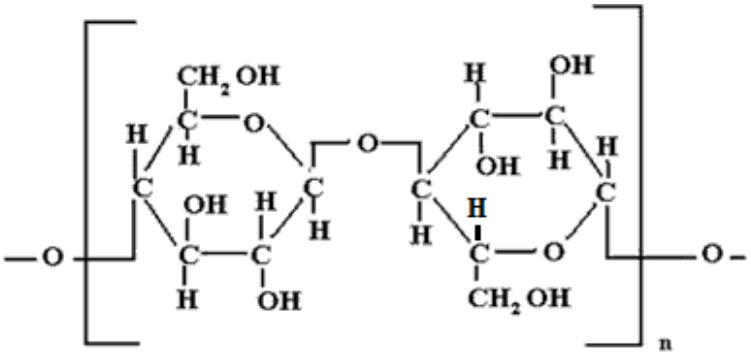

Fig. 2 Chemical structure of Cellulose

The figure (Fig. 2) above is cotton strands magnified 630 times by an electron microscope. On average cotton fibers are 1/8 – 2.5 inches long (0.32-6.35 cm) and the diameter of the fibers is generally between 16-20 micrometers, making is one of the finest natural fibers. When they are growing on the bole cotton fibers are round, but processing causes them to collapse into flat twisted ribbons. This twisted structure is part of what helps such short fibers grab onto each other as they are spun into threads and yarns.

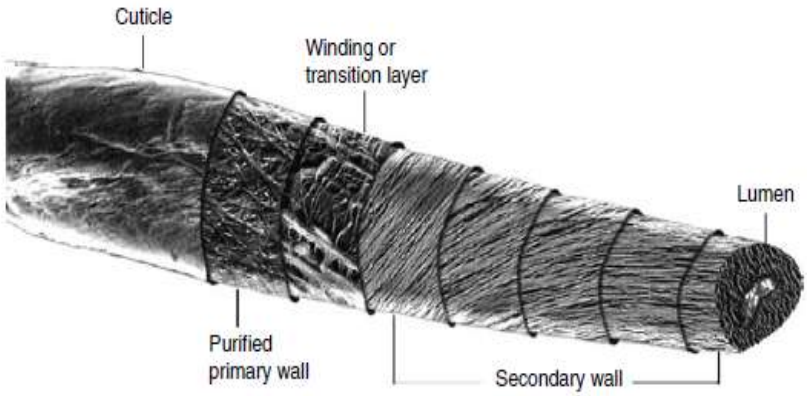

Fig. 3 Micro-structure of cotton

Cross-section (Fig. 3) of cotton fiber is somewhat ribbon like. The cell wall is rather thin and the

lumen occupies about two-third of the entire breadth and shows up very prominent in polarized light. Fibre cross-section becomes round when mercerized [10, 11].

1.4. Natural dyes

Natural dyes are dyes or colorants derived from plants, invertebrates, or minerals. The majority of natural dyes are vegetable dyes from plant sources –roots, berries, bark, leaves, and wood and other organic sources such as fungi and lichens. Natural dyes can be used on most types of material or fibre but the level of success in terms of fastness and clarity of color varies considerably. Users of natural dyes, however, also tend to use natural fibres, and so we will look in more detail at this group. Natural fibers come mainly from two distinct origins, animal origin or vegetable origin. Different mordanting techniques are called for with each category. In areas where synthetic dyes, mordants (fixatives) and other additives are imported and therefore relatively expensive, natural dyes can offer an attractive alternative [12].

1.5. History of Natural Dyes

Dyeing is ancient art which predates written records. It was practiced during the Bronze age in Europe. Primitive dyeing techniques included sticking plants to fabric or rubbing crushed pigments into cloth. Archaeologists have found evidence of textile dyeing dating back to the Neolithic period. In China, dyeing with plants, barks and insects has been traced back more than 5,000 years. Throughout history, people have dyed their textiles using common, locally available materials, but scarce dyestuffs that produced brilliant and permanent colors such as the natural invertebrate dyes, *Tyrian* purple and crimson kermes, became highly prized luxury items in the ancient and medieval world. Plant-based dyes such as *woad (Isatis tinctoria),indigo*, *saffron*, and *madder* were raised commercially and were important trade goods in the economies of Asia and Europe. Across Asia and Africa, patterned fabrics were produced using resist dyeing techniques to control the absorption of color in piece-dyed cloth. such as cochineal and logwood (*Haematoxylum campechianum*) were brought to Europe by the Spanish treasure fleets, and the dyestuffs of Europe were carried by colonists to America [13]. The first use of the blue dye, woad, beloved by the Ancient Britons, may have originated in Palestine where it was found growing wild. Western consumers have become more concerned about the health and environmental impact of synthetic dyes in manufacturing and there is a growing demand for products that use natural dyes. The European Union, for example, has encouraged Indonesian batik cloth producers to switch to natural dyes to improve their export market in Europe [14, 15].

1.6. Extraction process of colour component from natural dyes

Extraction of colour component from source natural dye material is important step for dyeing any textile substrate to maximize the colour yield. Moreover, standardization of extraction process and optimizing the extraction variables both, for a particular source natural dye material have technical and commercial importance on colour yield and cost of extraction process as well as dyeing cost. The natural dyes can be taken from various vegetable sources like flowers, stem or wood, roots, bark, etc. as well as animal sources and mineral sources. The colour component present in these sources needs to be extracted so that it can be applied suitably on textiles. Natural dyes of different origin can be extracted using aqueous method i.e. by using water for the extraction with or without addition of salt/acid/alkali/alcohol in the extraction bath, supercritical fluid extraction, enzyme assisted extraction, alcoholic/organic solvent extraction by using

relevant extracting equipment or soxhlet extraction method with use of alcohol and benzene mixture and finally to filterate, evaporate and to dry using ultra filtration equipment or centrifuge rotatory vacuum pump/or by extraction under reduced pressure [7, 16].

The collected source material is generally shadow dried in air or sun dried within a temperature range of 37-40 ℃ for the moisture content of the source natural dye material is reduced to 10-15% with proper drying since most of the material have moisture content of 40-80% and cannot be stored without drying. After drying, the source of natural dyes materials is carried out to extract the colouring materials in aqueous phase with or without addition of salt/acid/alkali/alcohol in the extraction bath. Extraction refers to separating the desired colour component by physical or chemical means with the aid of a solvent. Optimum conditions of extraction variables are determined through extracting the natural colour component from source material by varying extraction parameters of liquor and measuring the optical density of corresponding coloured liquor by using spectrophotometer [17].

1.6.1. Extraction through non-aqueous system

Due to increasingly stringent environmental regulations, supercritical fluid extraction (SFE) has gained wide acceptance in recent years as an alternative to conventional solvent extraction for separation of organic compound in many analytical and industrial process. In recent past decade, SFE has been applied successfully to the extraction of a variety of organic compounds from herbs, other plant material as well as natural colourants from source natural dye material. With increasing public interest in natural products, SFE may become a standard extraction technique for source natural dye material. Supercritical fluid extraction using alcohol as a solvent has provided an excellent alternative to the use of chemical solvents. Over the past three decades, supercritical alcohol has been used for the extraction and isolation of valuable compounds from natural products [18].

1.6.2. Aqueous extract of colour from fresh marigold

Dye from Marigold flowers are extracted separately in different proportion extraction process is carried out at a particular temperature range. Colouring materials from the flowers are extracted to dyeing the fibre.

For optimizing the extraction method of color component in aqueous medium, dried and finely separated marigold petals are immersed into extraction bath with or without addition of salt/acid/alkali/alcohol and then the color component is extracted in water employing a standard process using MLR 1:20 at 80 ℃ for 45 min at pH 11 and then it is filtered to obtain approximately 40% (w/w) coloured aqueous extract of mariegold. The aqueous extraction of dye liquor is carried out under varying condition, such as time of extraction, temperature of extraction bath, pH of extraction liquor, concentration of color-source material (powdered form of source natural dye material) and Material-to-liquor ratio (MLR) [19].

1.6.3. Chemistry involved in natural dyeing

The chemistry of bonding dyes to fiber is complex. Most of the natural dyes have no substantivity on cellulose or other textile fibres without the use of a mordant. The majority of natural dyes need a mordanting chemical (preferably metal salt or suitably coordinating complex forming agents) to create an affinity between the fibre and dye or the pigment molecules of natural colourants. These metallic salts as mordant form metal complexes with the fibres and the dyes. After mordanting, the metal salts anchoring to the fibres,

attracts the dye/organic pigment molecules to be anchored to the fibres and finally creates the bridging link between the dye molecules and the fibre by forming coordinating complexes (Fig. 4). Thus, for proper fixation of natural dyes on any textile fibre, mordanting is essential in most of the cases. The said mordanting can be accomplished either before dyeing (premordanting), or during dyeing (simultaneous mordanting) or after dyeing (post mordanting) [20, 21]. Aluminum Sulphate or other metallic mordants anchored to any fibre, chemically combine with certain mordantable functional groups present in the natural dyes and bound by coordinated/covalent bonds or hydrogen bonds and other interactional forces as shown below:

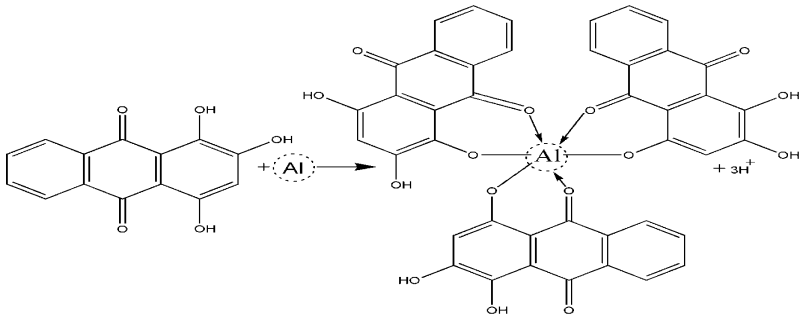

Fig. 4 Formation of coordinated complex between natural dye molecules and metallic mordant for dye fixation on mordant textiles

1.7. Mordanting agent

Mordants are substances which are used to fix a dye to the fibres. They also improve the take-up quality of the fabric and help improve color and light-fastness. The term is derived from the Latin *mordere*, to bite. Some natural dyes, indigo for example, will fix without the aid of a mordant; these dyes are known as 'substantive dyes'. Others dye, such as madder and weld, have a limited fastness and the colour will fade with washing and exposure to light.

Traditionally, mordants were found in nature. Wood ash or stale urine may have been used as an alkali mordant, and acids could be found in acidic fruits or rhubarb leaves (which contain oxalic acid), for example. Nowadays most natural dyers use chemical mordants such as alum, copper sulphate, iron or chrome [18, 22].

2. Experimental

2.1. Materials

100% cotton knitted fabric (bleached) of 160 gsm collected from Impress Newtex Composite Textiles Ltd, Bangladesh is used as cotton knit fabric for dyeing. Marigold flower is used for the extraction of natural dyes. As mordanting Agent Potassium Dichromate ($K_2Cr_2O_7$), Ferrous Sulphate ($FeSO_4$), Nickel (II) Sulphate ($NiSO_4$), Copper Sulphate ($CuSO_4.5H_2O$), Potash Alum [$K_2Al_2(SO_4)_3.24H_2O$] are used. Felson NOF is used as washing agent for soaping of sample fabrics after dyeing. ECE detergent is used for color fastness wash testing which is provided by Impress Newtex Composite Textiles Ltd. Gulbar salt used for dye exhaustion to the fabric.

2.2. Instruments

IR Dyer, Electronic Balance, Hot Air Dryer, Rota Wash, Crock meter, Perspiration fastness tester, Xenon Arc light fastness tester, Washing machine.

2.3. Methodology

2.3.1. Dye Extraction

Firstly marigold flower is collected, and then the Patel is separated and finally dried on sunlight (8 hours), subsequently dry in room due to preserve their natural colorant. The natural dyes were extracted by boiling the above substrates in water without any chemicals. 100g of dry substrate was taken in a stainless steel container with 5 litres of water without any chemical heated them upto 60^{o}C temperature (not exceed boiling temp.), kept the heated flower for a while to cooling and again heated them up to 60^{o}C temperature. **Recipe:**

Flower - 100gm
Water- 5 litre.
Temperature- 60^{o}C

2.3.2. Mordanting

A common principle during mordanting (Fig. 5) with different mordanting agents are performed for this article –

Recipe:

Mordanting agent 5 g/l
Time 60 min
Temp 100^{0}C
M : L 1 : 20

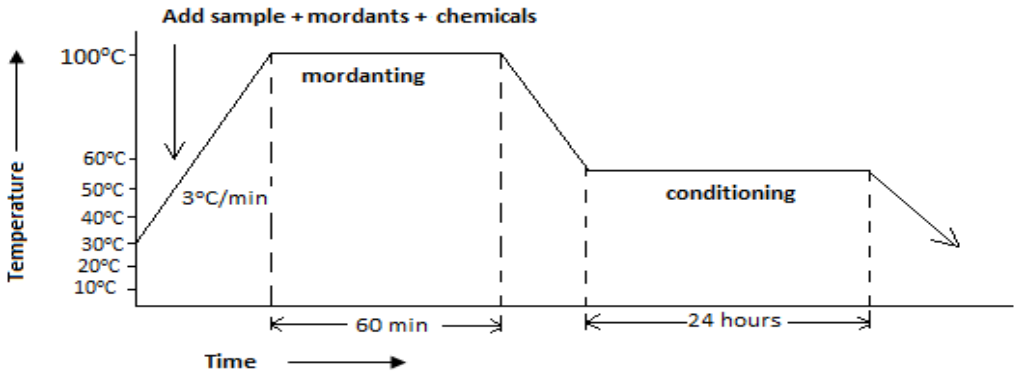

Fig. 5 Mordanting Curve

2.3.3. Dyeing

A common principle during dyeing (Fig. 6) with different mordanting agents are performed for this article –

Recipe

Dyes 20 g/l
Salt 5g/l
Levelling agent 1g/l
Time 60 min
Temp 60^{0}C

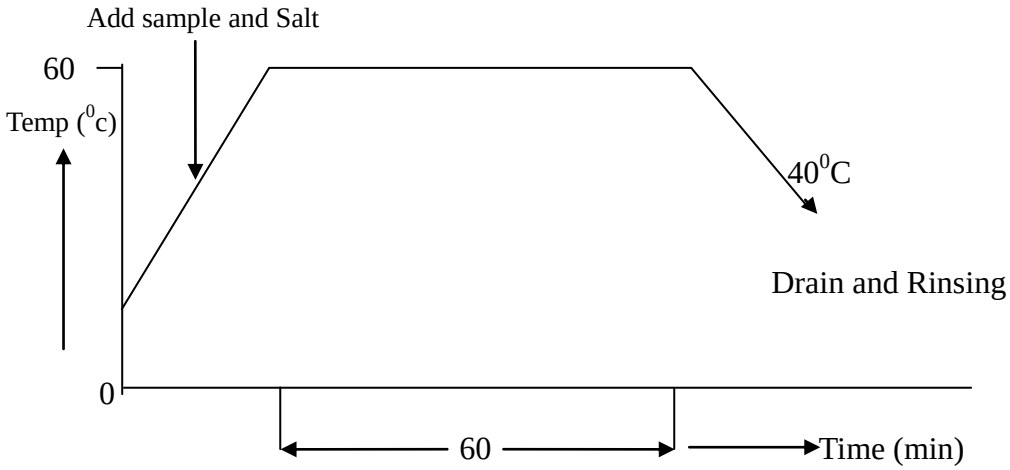

Fig. 6 Dyeing Curve

2.3.4. Washing

At the end of the dyeing process the samples are washed (Fig. 7) by following recipe and parameters:

Soaping agent - 1 g/l (5% stock solution)

M: L- 1:20

Temperature- 40^oC

Time- 10 min

Then the samples are cold washed by hand dried by Hot Air Dryer.

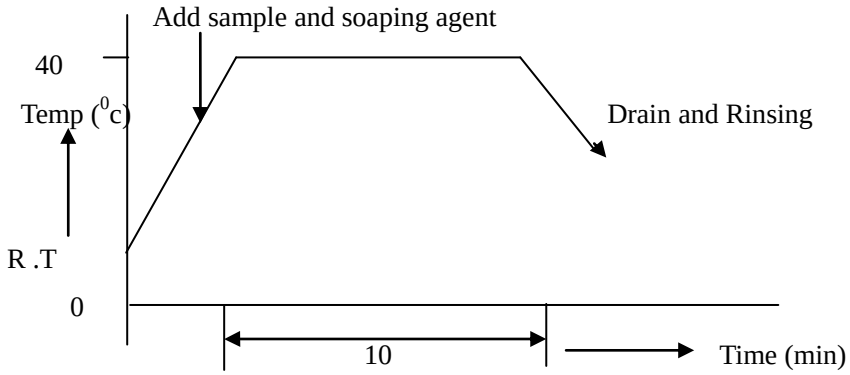

Fig. 7 Washing Curve

2.4. Color fastness test Procedure

We are projected to measure color fastness to three agencies:

- Color fastness to wash
- Color fastness to perspiration/saliva
- Color fastness to water
- Color fastness to rubbing
- Color fastness to light

2.4.1. Color fastness to wash

Method: ISO 105 C06

Test specimen:

- Sample fabric size – 100 mm × 40 mm
- Multifibre fabric – 100 mm × 40 mm

Recipe of test Solution:

Soda Ash – 1g/l
ECE Detergent- 4 g/l
Steel Ball- 25 pieces/ pot
Distilled water – 1000L
Temperature- 60^{o}C
Time- 30 min

2.4.2. Measurement of Color fastness to perspiration

Method: ISO 105 E04

Test specimen:

- Sample fabric size – 100 mm × 40 mm
- Multifibre fabric – 100 mm × 40 mm

Recipe of test Solution:

i) Alkaline Solution:

L-Histidine monohydrochloride monohydrate ($C_6H_{10}ClN_3O_2.H_2O$) – 0.50 ± 0.001 g/L
NaCl – 5.00 ±0.01 g/L
Disodium hydrogen orthophosphate ($Na_2HPO_4.2H_2O$) – 2.5 ± .01 g/L
P^H – 8 ± .02 (Adjust by 0.1 N NaOH)
Distilled water- 1000ml

ii) Acidic Solution:

Histidine monohydro chloride monohydrate ($C_6H_{10}ClN_3O_2.H_2O$) – 0.5 ± 0.001 g/L
NaCl – 5.00 ±0.01 g/L
Sodium di-hydrogen orthophosphate ($NaH_2PO_4.2H_2O$) – 2.2 ± 0.01 g/L
P^H – 4.3 ± 0.2 (Adjust by 0.1 N NaOH)
Distilled water-1000ml

iii)Saliva:

For saliva test a standard recipe (Table 1) is used which is illustrated in.

Table 1 Saliva test reagents and concentration

Reagent	amount
Lactic acid	3.0g/l
Urea / carboamide	0.2g/l
NaCl	4.5g/l
KCl	0.3g/l
NH_4Cl	0.4g/l
Na_2SO_4	0.3g/l
Distilled water	1litre

2.4.3. Measurement of Color fastness to Wash

Method: (ISO 105 E01)

Test specimen

- Sample fabric size – 100 mm × 40 mm
- Multifibre fabric – 100 mm × 40 mm

Reagents:

- Distilled water or de-ionized water.

2.4.4. Measurement of Color fastness to perspiration rubbing

To measure the color fastness to rubbing we carried out it for two conditions:

1) Dry rubbing
2) Wet rubbing

Method: ISO 105 X12

Test specimen:

Dyed fabric – 14 cm × 5 cm

White Test Cloth - 5 cm × 5 cm

2.4.5. Measurement of Color fastness to Light

Method: ISO 105 B02

Test specimen:

- Sample fabric size – 45 mm × 130 mm

Machine variables:

Irradiance – 1.10 W/m^2

Black panel temperature – 50^0C

Chamber air temperature – 42^oC

Relative Humidity (RH %) – 50%

Run time – 24 hrs

3. Results and Discussions

3.1. Color fastness to Wash

Ratting for color fastness to wash (staining) is shown in Table 2 indicates the effect of wash fastness. It is seen that the fastness mordanted through $CuSO_4.5H_2O$, $FeSO_4$, $K_2Cr_2O_7$ and Potash Alum are better than $SnCl_2$.

Table 2 Ratting for color fastness to wash (staining)

Used Mordanting agent	Color staining grade to multifibre fabric					
	Acetate	Cotton	Nylon	Polyester	Acrylic	Wool
$K_2Cr_2O_7$	4-5	4	4-5	4-5	4-5	4-5
$FeSO_4$	4-5	4-5	4-5	4-5	4	4-5
$NiSO_4$	4-5	4	4-5	4-5	4-5	4-5
$CuSO_4.5H_2O$	4-5	4-5	4-5	4-5	4	4-5
Potash Alum	4-5	4-5	4-5	4-5	4-5	4-5
$SnCl_2$	3-4	4	3-4	2-3	3	3-4

Potash Alum show better color fastness to wash than others mordanted natural dyed fabric. So, from the above data we have found that, color fastness to wash shows excellent grading for color staining almost between 4-5. But change in color grading is lies between 3-4 for $K_2Cr_2O_7$, Nickel II Sulphate and $SnCl_2$.grading 4 is for $FeSO_4$ and $CuSO_4.5H_2O$. The highest grading is found for pottas alum (4-5) which is shown in Fig. 8

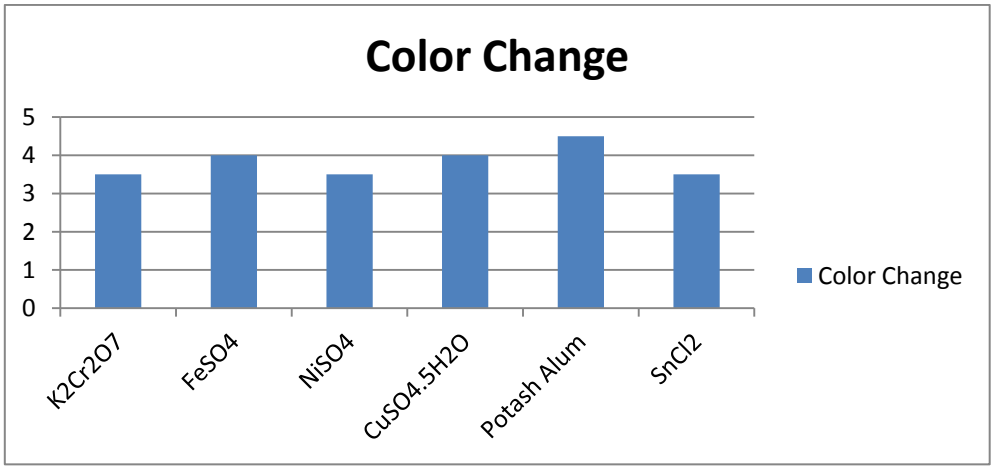

Fig. 8 Comparison of Color change grading for wash fastness

3.2. Grading for color fastness to Perspiration/Saliva

Color fastness to Perspiration/saliva is graded in three steps for color staining in the multifibre fabric and color change of the sample. One step is made for alkaline; other is for acidic perspiration and another for saliva. Two individual respective grey scales is used for color stain and color change (Fig. 9). The results are given as following:

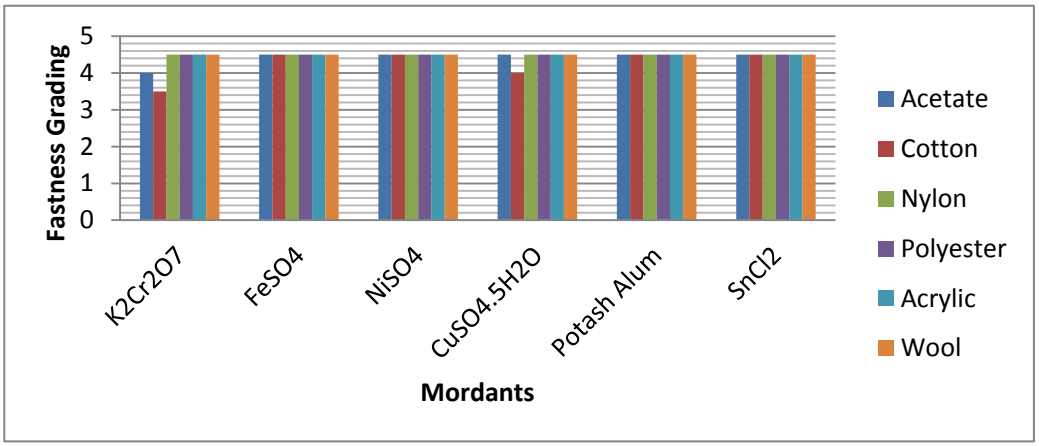

Fig. 9 Comparison of Color staining for alkaline perspiration fastness

From the above data we found that, alkaline perspiration fastness grads for color staining show good results almost 4-5 except $K_2Cr_2O_7$ and $CuSo_4.5H_2O$ reported in Fig. 10. Lowest staining grade found on cotton and acetate is 3-4 and 4 respectively (Fig. 11). Changes in color grads are also good. The highest grades found for $FeSO_4$ is 4-5 and rest of them are almost same i.e. 4 .

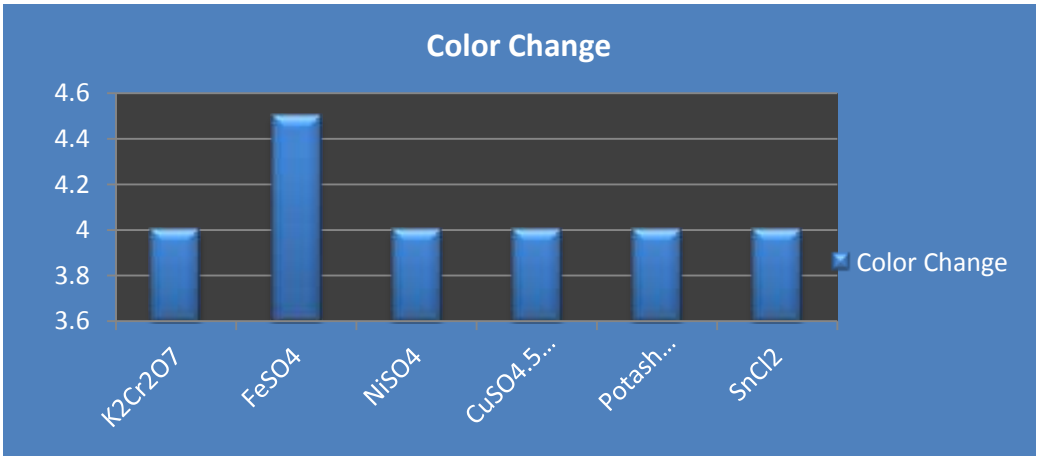

Fig. 10 Comparison of Color change grading for alkaline perspiration fastness

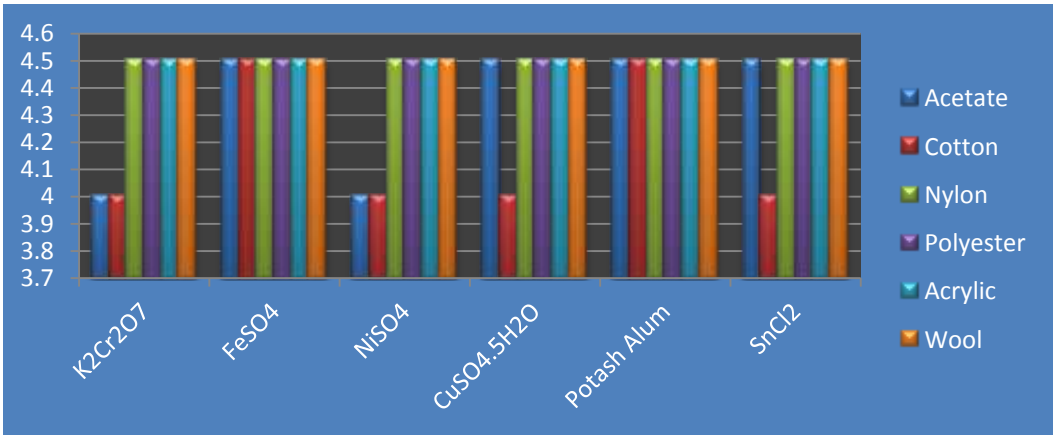

Fig. 11 Comparison of Color staining for acidic perspiration fastness

Table 3 Color change grading for acidic perspiration fastness

Used Mordanting agent	Color change grade
$K_2Cr_2O_7$	4
$FeSO_4$	4-5
$NiSO_4$	4
$CuSO_4.5H_2O$	4
Potash Alum	4-5
$SnCl_2$	4

It is found that acidic perspiration grades are almost same to alkaline. Ranges are almost between 4 to 4-5 illustrated in
Table 3. Changes in color grads are also good. It is also lies between 4 to 4-5 reported in above table.

Table 4 Color staining for color fastness to saliva

Used Mordanting agent	Color staining grade to multi fibre fabric					
	Acetate	Cotton	Nylon	Polyester	Acrylic	Wool
$K_2Cr_2O_7$	4-5	4-5	4-5	4-5	4-5	4-5
$FeSO_4$	4-5	4	4-5	4-5	4-5	4-5
$NiSO_4$	4	4-5	4-5	4-5	4-5	4-5
$CuSO_4.5H_2O$	4-5	4-5	4-5	4-5	4-5	4-5
Potash Alum	4-5	4-5	4-5	4-5	4-5	4-5
$SnCl_2$	4-5	4	4-5	4-5	4-5	4-5

From the above data (Table 4) we found that, color fastness to saliva grads for color staining show good results almost 4 to 4-5. Changes in color grads are also good. The highest grades found 4-5 and lowest is 4.

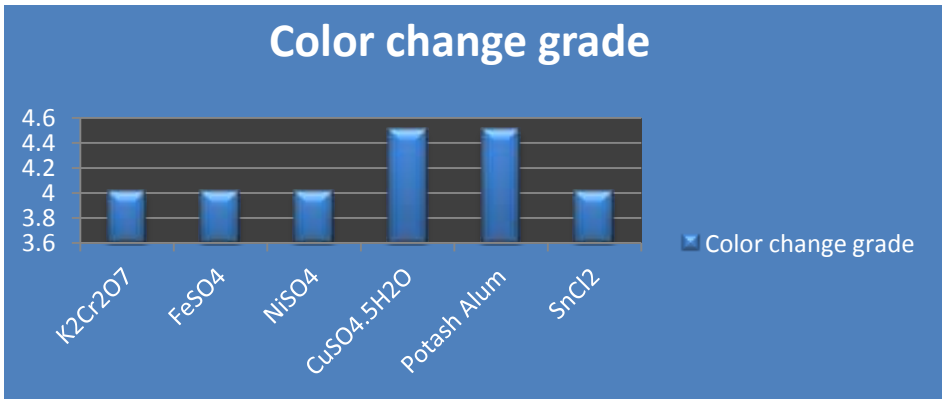

Fig. 12 Comparison of Color change grading for color fastness to saliva

The **Fig. 12** illustrates color fastness to saliva for different mordanting agents used during the coloration of fabric through natural dyes.

3.3. Grading for color fastness to water

Table 5 Color staining for fastness to water

Used Mordanting agent	Color staining grade to multifibre fabric					
	Acetate	Cotton	Nylon	Polyester	Acrylic	Wool
$K_2Cr_2O_7$	4-5	4	4-5	4-5	4-5	4-5
$FeSO_4$	4-5	4-5	4-5	4-5	4-5	4-5
$NiSO_4$	4	4	4-5	4-5	4-5	4-5
$CuSO_4.5H_2O$	4-5	4-5	4-5	4-5	4-5	4-5
Potash Alum	4-5	4-5	4-5	4-5	4-5	4-5
$SnCl_2$	3-4	4	4-5	4-5	4-5	3-4

From the above data (Table 5) we have found that, color fastness to water shows excellent grading for color staining almost between 4 to 4-5 reported in. Color change grade is also good. The highest grading is found (4-5) and lowest is 4 illustrated in Fig. 13.

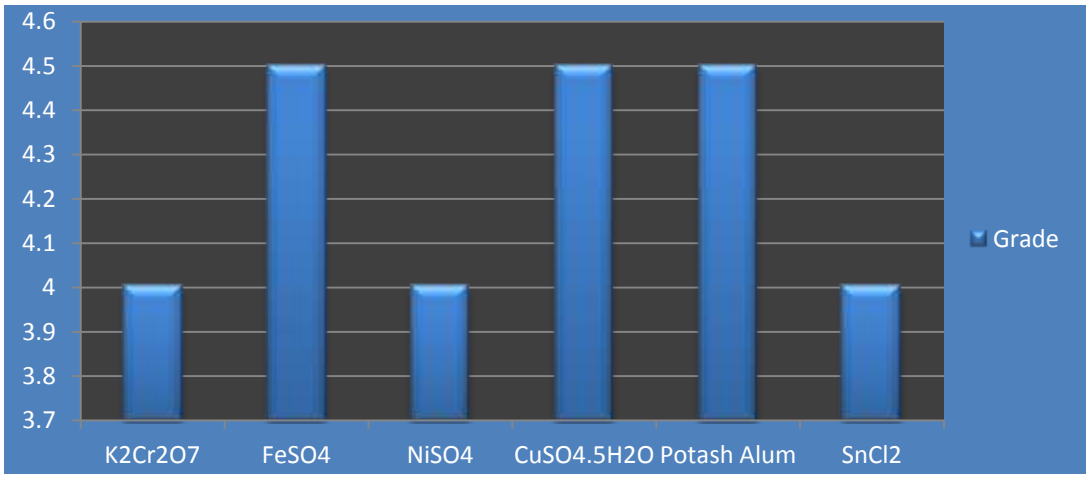

Fig. 13 Comparison of Color change grading for fastness to water

3.4. Grading for color fastness to rubbing

Color fastness to Perspiration is graded in two steps for color staining in the White test cloth. One step is made for Dry rub (Table 6) and other is for Wet rub. Grey scale is used for measuring color stain. The results are reported in.

Table 6 Grading for Dry rubbing fastness of different samples

Used Mordanting agent	Grade
$K_2Cr_2O_7$	5
$FeSO_4$	4-5
$NiSO_4$	5
$CuSO_4.5H_2O$	5
Potash Alum	5
$SnCl_2$	4-5

It is observed from the test that rubbing fastness properties is very good. Highest Dry rub grading is 5 and Wet rub grading is 4-5 (Fig. 14). The lowest grading is found in $SnCl_2$ .lowest Dry rub grading is 4-5.

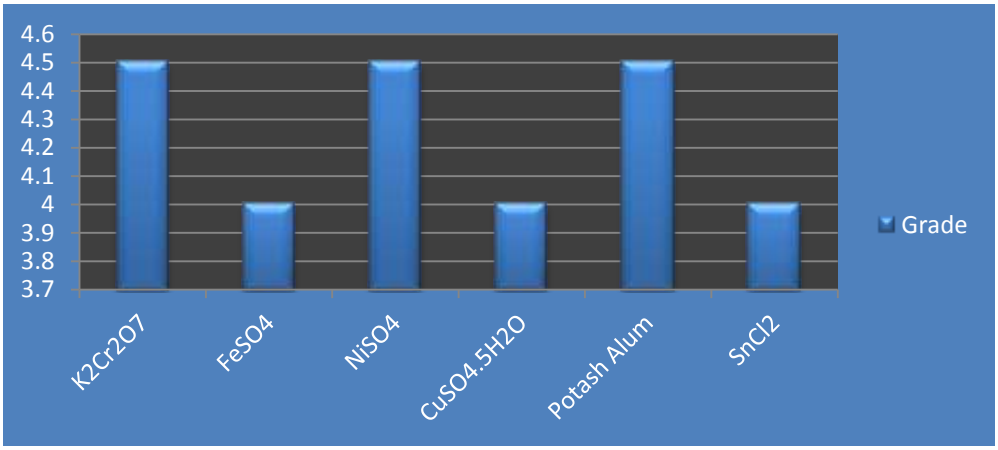

Fig. 14 Comparison of Wet rubbing fastness of different samples

3.5. Grading for color fastness to Light

Sample was exposed to light for 24 hours. As blue wool scale is also faded with the sample, so it is possible to compare the grades among different samples reported in

Fig. 15.

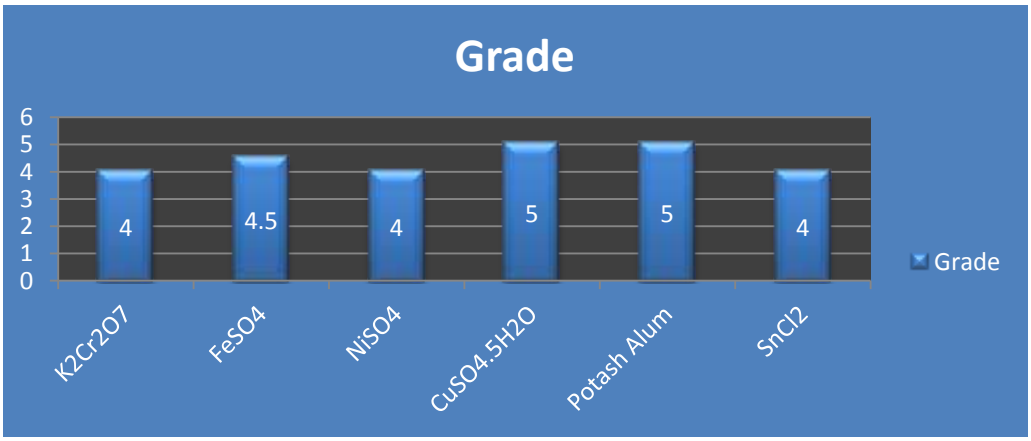

Fig. 15 Comparison of Grading for Light fastness of different samples

3.6. Measurement of COD value of effluent

Here $SnCl_2$ shows highest COD value having 1635 mg/l and $CuSO_4.5H_2O$ shows the lowest having 760 mg/l, $FeSO_4$ also show lower COD as in Fig. 16. But $NiSO_4$ and $K_2Cr_2O_7$ mordanted effluent also shows higher COD illustrated in.

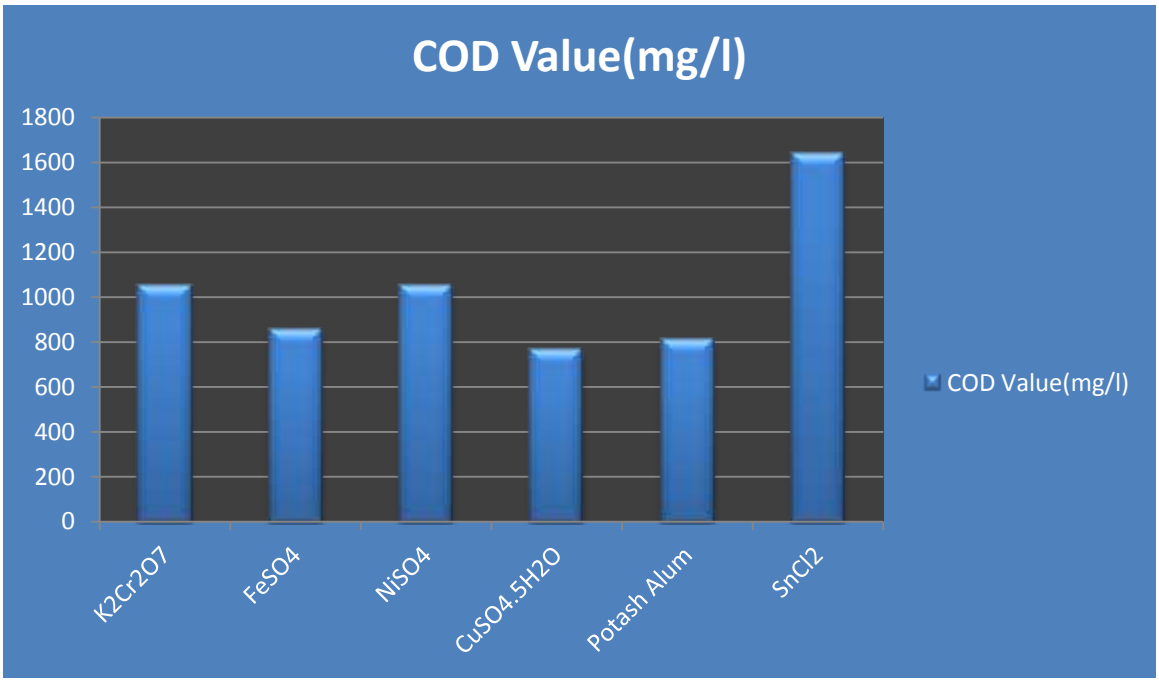

Fig. 16 Comparison of COD value of different effluent

4. Conclusion

Marigold flowers can be used to extract dye which can be used as natural floral dye for coloring textile fabric. These natural dyes are cost effective, eco-friendly and renewable and has no allergic action on skin. There is one common particular method involves in natural dyeing, mordant application is also a common method but dye extraction method varies. However dyeing efficiency depends on choosing right extraction method and mordant application. The sample fabric must be well scoured and bleached.

For this article a well scoured and bleached sample is taken and Marigold flower is chosen for dyeing the fabric with the assistance of different mordanting agents. The purpose of this research is to extract natural dyes and apply on cotton knitted fabric using accurate mordant. It is found out the fastness properties of the dyed samples as well as to evaluate the COD of the effluent. As natural dyes extraction and application has not any particular method so it is so difficult to choose the right method for particular natural dyeing. But it is extremely tried to find out some good mordants with good fastness properties through the extraction of natural dyes.

5. References

1. Zhang X, Laursen RA. Development of mild extraction methods for the analysis of natural dyes in textiles of historical interest using LC-diode array detector-MS. ***Analytical Chemistry.*** 2005, 77(7):2022-2025
2. Samantaa AK, Agarwal P. Application of natural dyes on textiles. ***Indian Journal of Fibre and Textile Research.*** 2009, 34:384-399
3. Jothi D. Extraction of natural dyes from African marigold flower (Tagetes ereectal) for textile coloration. ***AUTEX Research Journal.*** 2008, 8(2): 49-53
4. Bechtold T, et al. Extraction of natural dyes for textile dyeing from coloured plant wastes released from the food and beverage industry. ***Journal of the Science of Food and Agriculture.*** 2006, 86(2):233-242
5. Leona M, Stenger J, and Ferloni E. Application of surface-enhanced Raman scattering techniques to the ultrasensitive identification of natural dyes in works of art. ***Journal of Raman Spectroscopy.*** 2006, 37(10): 981-992
6. Valianou L, Karapanagiotis I, and Chryssoulakis Y. Comparison of extraction methods for the analysis of natural dyes in historical textiles by high-performance liquid chromatography. ***Analytical and bioanalytical chemistry.*** 2009, 395(7):2175-2189
7. Sivakumar V, Vijaeeswarri J, and Anna JL. Effective natural dye extraction from different plant materials using ultrasound. ***Industrial Crops and Products.*** 2011, 33(1):116-122
8. Kim HJ, and Triplett BA. Cotton fiber growth in planta and in vitro. Models for plant cell elongation and cell wall biogenesis. ***Plant physiology.*** 2001, 127(4):1361-1366
9. Meinert MC and Delmer DP. Changes in biochemical composition of the cell wall of the cotton fiber during development. ***Plant Physiology.*** 1977, 59(6):1088-1097
10. Ruan YL, Llewellyn DJ, and Furbank RT. Suppression of sucrose synthase gene expression represses cotton fiber cell initiation, elongation, and seed development. ***The Plant Cell.*** 2003, 15(4):952-964
11. John ME, and Keller G. Metabolic pathway engineering in cotton: biosynthesis of polyhydroxybutyrate in fiber cells. ***Proceedings of the National Academy of Sciences.*** 1996, 93(23):12768-12773
12. Cardon D. Natural dyes: sources, tradition, technology and science. 2007: Archetype.
13. Melo MJ. History of natural dyes in the ancient mediterranean world. ***Handbook of natural colorants.*** 2009:3-20
14. Siva R. Status of natural dyes and dye-yielding plants in India. CURRENT SCIENCE-BANGALORE-, 2007, 92(7): 916
15. Ferreira ES, et al. The natural constituents of historical textile dyes. ***Chemical Society Reviews.*** 2004, 33(6):329-336
16. Wongcharee K, Meeyoo V, and Chavadej S. Dye-sensitized solar cell using natural dyes extracted from rosella and blue pea flowers. ***Solar Energy Materials and Solar Cells.*** 2007, 91(7)566-571
17. Zhou H, et al. Dye-sensitized solar cells using 20 natural dyes as sensitizers. ***Journal of Photochemistry and Photobiology A: Chemistry.*** 2011, 219(2):188-194
18. Samanta AK, and Konar A. Dyeing of textiles with natural dyes. 2011: INTECH Open Access Publisher
19. Sowbhagya H, Sampathu S, and Krishnamurthy N. Natural colorant from marigold-chemistry and technology. ***Food Reviews International.*** 2004, 20(1):33-50
20. Kadolph S. Natural dyes: a traditional craft experiencing new attention. ***Delta Kappa Gamma Bull.*** 2008, 75(1):14-17
21. Furry MS, and Morrison BV. Home dyeing with natural dyes. 1935: US Department of Agriculture.
22. Samanta A, Singhee D, and Sethia M. Application of single and mixture of selected natural dyes on cotton fabric: A scientific approach. ***Colourage.*** 2003, 50(10):29-42