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Cotton Dyeing - A Living Art

Dr. T.R. Loknathan has a Ph. D. in plant breeding. He is currently working as a Principal Scientist in the Division of Crop Improvement at ICAR-CICR, Nagpur. He is pursuing his research on genetic enhancement of cotton.

GUEST COLUMN

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Introduction

There is always a certain amount of colouring matter prevalent in the form of endochrome (colour imparting organelle) located in the walls of the fibre immediately surrounding the inner cavity or lumen. In Egyptian cotton it is more pronounced, assuming a reddish brown or golden colour. It turns whiter in colour when exposed to sunlight and darker when exposed to moist heat like the steaming process involved in doubling. Dr.Schunk, after a careful examination of the colouring matter associated with the Egyptian and East Indian cotton, noticed two kinds, one of which is readily soluble in alcohol which he called A and the other soluble in boiling water, which he termed B.

These natural colour manifestations were limited and man felt the need to resort to artificial colouring. Dyeing is the application of dyes (colouring matter) to the yarns, fabrics, cloths and attain colour fastness. The practice of dyeing is quite ancient, existing in many civilizations. With the development of yarn, fabric and cloth-making, dying became more popular as plain white textiles gained an ornamental value once they were coloured.

History of Dyeing

The word dye originated in the 12'th century AD and is derived from middle English 'diei' and from the ancient English 'dag' and 'dah'. The primary source of dyes has been natural dyes extracted from plants, animals and insects since ancient times.

Dyes have been prevalent in old civilizations viz., Peruvian (red dye), Indus Valley civilization (indigo) in Mohenjo-dharo, Harappan remains (purple, etc).

Plant extracts used as dyes were common from plants like madder, woad (northern indigo, indigo (tropical woad) American logwood, Brazil-wood (source of most of the dyes in the middle– ages). The American Quercitron barks gave the colour yellow. Various shades of the same colour are produced from various barks creating variegated shades. Basically, four colours viz., Red, blue, yellow and brown are in existence. The combination of these four colours create various patterns and shades.

Insect Dyes: These are extracts from insects like Cochneal , Kermes (mostly used in Europe), and also fish dyes used in Byzantine during ancient times.

The earliest known dyeing of flax fibres was discovered in an ancient prehistoric cave in the Republic of Georgia which dates back to 34000 BC. More evidence of textile dyeing in the Neolithic period was discovered in the city of Catalhuyk in Southern Anatolia as traces of red dye (ochre), an iron oxide pigment obtained from clay. In China, dyes extracted from plant parts, barks and insects have been in use for 5000 years. Early evidence from the Sind province in Pakistan - cotton dyed with a vegetable dye - was found in Mohenjo-dharo remains (3rd millenium B.C.). This colour was obtained from madder and in combination with a blue dye obtained from indigo was introduced to other regions through trade.

Cochneal dyes and Kermes from insects and plant dyes like woad and madder were part of the main economies of Asia and Europe until the discovery of synthetic dyes in the mid -19th century.

The first synthetic dye was William Perkin's mauveine in 1856 followed by another important synthetically designed dye duplicating red dye from madder. Alizarin another dye obtained from coal tar was designed in 1869. The advent of these synthetic dyes led to the collapse of the art of dyeing with natural dyes in the textile economy of Britain and Europe in the mediaeval times. With the rising domination of the commercial dyeing processes, began the decline of the art of dyeing and the numbers of skilled artisans practising the ancient art block print also dwindled.

Concept of Dyeing:

Dyeing is the application of colours or pigments to textile fibres, yarns or fabrics, ensuring an element of colour fastness. It is done by using a chemical solution where the fibre expresses affinity depending on the dye and particular chemical material. Dyeing is achieved by absorption, diffusion and bonding of the pigment in the fibre, depending on time and temperature. The bond may be strong or weak depending on the dye or chemical used.

The essential process of dyeing has changed a little over time. The dyeing material is put in a pot of water for extraction. The textile to be coloured is added to it and a slight heat is applied till you get the desired result. Mordants may be added to achieve colour fastness. The dyeing can be achieved depending on the dye in various fibre processing stages. Dyeing can be done before spinning or weaving (dyeing of wool), after spinning ((yarn dyeing) and dyeing in pieces (fabric).

Dyeing may be done to the entire fabric or in patches on the fabric by printing. Printing application is achieved by block printing, an ancient art practised by skilled artisans endowed with a hereditary legacy. It is a process creating patterns on textiles, selective dyeing on textile, not the whole of it. Some of the traditional Navajo printing still exist in USA. Block printing is widely prevalent in various parts of India, like Jaipur in Rajasthan and kalamkari printing in Andhra Pradesh. Few people have come and learnt the art of Jaipur block printing emerging as able textile designers in USA. The few artisans still remaining are dwindling in numbers,

Types of dyes:

These are classified as Natural dyes and Synthetic dyes based on their origin.

Natural dyes:

These are obtained from vegetable and plant parts like roots, berries, barks, leaves and wood; Cochneal insects and Kermes and other biological matter like fungi. Natural mordants ((used as colour fixatives or colour binders to the fibre) like tannins are derived from oak galls, pigments and a wide range of other plant parts; pseudo-tannins like plant-derived oxalic acid and ammonia from stale urine. Plants that bio-accumulate aluminium have been used like club mosses. Symplocus genus used for dyeing are an endangered species in Europe. Plant dye producing plants like woad, indigo, saffron and madder, etc. have been in cultivation since ages in the commercial trade economies of Africa, Europe and Asia and America.

Many available local dyestuffs have been used in different places. Some scarcely available dyes from natural invertebrates,

plants (Haematoxylum campachianum.), Tyrian blue and Kermes (crimson red) are valued as luxury ones due to their brilliant colour and permanence.

Mordants are often used with Natural dyes. the word mordant originates from the Latin word 'mordere ' meaning to bite and improves colour fastness. Mordants are metal salts which form stable molecular complexes with natural dyes and natural fibres. Most commonly used mordants are alum (a metal salt, potassium aluminium silicate) and iron (ferrous sulphate). But many other metal salts in use earlier have now been abandoned due their toxic nature and ecological health. Many non - metal mordants like pseudo - tannins were also used as apt binders to these dyes.

In natural dyes there are 'fast' dyes which bind very strongly to the molecular structure of mordant and fibre. Another group are the 'fugitive' dyes which do not bind and fade away after being treated with the fibre. Natural dyes are obtained from all berries, beets, cabbage, spinach and most of the flowers (although a few flowers are used as natural dyes).

Common natural dyestuff has been obtained from various dye yielding plants belonging to different genera and species distributed in tropical, sub- tropical and temperate regions in diverse geographical habitats, spread across the continents of both the New and the old words. They have flourished within various tribes in different countries as craft weavers (ancient dyeing art preservers).

The natural dyestuff in existence were red, pink, blue, purple, brown, black, green, yellow, pink, etc. Each of them was characteristic and manifested in diverse plant species. A combination of few produced diverse shades practised since ages.

The various natural colour dyes viz. Red and pink, yellow, orange, blue, purple, green, brown, black are manifested in different plant species and different genera distributed across the world in diverse habitats. These have been utilised by a diverse sect of craft dyers of differing ethnicity in different parts of the world.

Natural dye plants, their geography and the native craft dyers (tribes as stakeholders :

The natural dye colours like red and pink, yellow, blue, purple, violet, green, brown, black are distributed in many diverse species, genera of invertebrates, plants, animals, insects, lichens, etc. These diverse genera are to be found in different ecological regions. The diverse dye producing plant species within a genera are endemic to these regions. Ancient dyeing techniques were practised by the natives inhabiting the region. These native tribes flourished in their art of dyeing and block printing (creating patterns) and the local textile industries developed, taking on the distinctive characteristic of their respective domestic regions. These local textile industries continued to flourish in the mediaeval 18th century till the entry of the synthetic dyes.

Some of the plant species cited here like madder, alkanna, indigo, dyer's broom, Juglans, ochre, logwood , Brazil wood, many more species like lichens, molluscs, snails, lac insects, Cochneal have been explored. Some are widespread and some are endemic. The native tribes, like, Navajo basket and rug weavers, Japanese Shibori printers, European craft dyers, Indonesian batik cloth weavers, native Indian craft dyers (Jaipur block printers, Ponduru craft dyers, Himalayan madder dyers, etc), flourishing in Asia have all put the dyeing industry on the global map.

Different fibres require different mordanting. They are broadly classified into two categories.

1. Cellulose fibres: Cotton, linen, hemp, ramie and rayon.

2. Protein fibres: Angora, wool, mohair, cashmere, silk, soy, leather and suede.

Both the fibres require different mordants for dyeing due to their differing molecular structures, differing in their binding abilities. Cellulose fibres have less affinity for dyes as compared to Protein fibres. The best thing for a cellulose fibre is to first use tannin and then add alum.

(To be continued...)

(The views expressed in this column are of the author and not that of Cotton Association of India)

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Contd. from Issue No. 11 dated 25th August, 2020

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Some popular natural dyes prevalent amongst craft dyers and fashion industry are:

Animal based -

1. Cochneal insects (red).
2. Cow urine (Indian yellow)
3. Lac insect (red and violet)
4. Murex snail (purple)
5. Octopus / cuttle fish (sepia brown)

Plant based –

1. Catechu (brown)
2. Gamboge tree resin (dark mustard yellow)
3. Chestnut hulls (peach to brown)
4. Himalayan rhubarb root (bronze and yellow)
5. Madder roots (yellow and orange)
6. Indigofera leaves (blue)
7. Kamala seed pods (yellow)
8. Mangosteen peel (green, brown, dark brown, purple, crimson)
9. Myrobalan fruit (yellow, green, black, source of tannin)
10. Pomegranate rind (yellow)
11. Teak leaf (crimson to maroon)
12. Weld herb (yellow)
13. Juglans nigra or black walnut hulls (brown, black source of tannin)
14. Rhus typhina or Sumac tree (brown, source of tannin).

Many hundreds of mordants are being used with many dyes resulting in viable dye combinations. The traditional craft dyers prefer natural dyes since they are multi - coloured and permanent in nature, unlike the single coloured synthetic dyes.

2. Synthetic dyes: These are known as coal -tar dyes, since they were mostly produced from coal-tar in earlier years. They are organic molecules synthesised artificially to suit the various fibres. They are of single colour types and more of a permanent nature. They are mainly of two types - acidic dyes and basic dyes - in a broader sense. The binding of the dyes to the fibres are based on solubility and chemical properties of the chemical.

Acidic dyes: These are mostly the water-soluble anionic dyes which combine with the cations of the fibres resulting in a dyed fibre.

These dyes are used for dyeing of wool, silk, nylon and mostly modified acrylic fibres in a neutral or acidic bath. Acidic dyes are not cellulosic in nature. Examples are aniline, alizarin pure blue 88, etc.

Basic dyes: These dyes are water-soluble cationic mostly combining with salts. They are mostly applied to nylon fibres.

Dyes have been further classified into various types based on their mode of action on fibres.

Direct or substantive dyes:

Direct dyes are basically treated in a neutral or slightly alkaline bath using potassium chloride or potassium sulphate or potassium carbonate. These are used for treating cotton, paper, leather, nylon, etc. They are also used as pH indicators and biological stains.

Mordant dyes:

These dyes require mordants which improve colour fastness against water, light and perspiration. Natural dyes are mostly mordant dyes which have been described a lot in history. Thirty percent of the mordant dyes or chrome dyes are used for wool especially for black and navy shades. The choice of the correct mordant is very important as different mordants can change the final colour. The mordant potassium di - carbonate is added after dyeing. Most of the metallic mordants of a slightly heavy metal category are hazardous chemicals.

Vat dyes:

These dyes are insoluble in water and are incapable of dyeing. However, the reduction in alkaline liquor often produces a water- soluble alkaline salt solution. This takes the form of a colourless solution. Hence it is known as leuco dye.

It has an affinity with the textile fibre. Subsequent oxidation reforms the original insoluble dye. The iconic blue colour of the denim is due to indigo, the original vat dye.

Reactive dyes:

These dyes utilise a chromophore substituent which gets attached to the substrate of the fibre. The covalent bond of the reactive dye formed makes the dye the most permanent and stable amongst the dyes. Cold reactive dyes viz., Procion MX, Cibacron F are easy to handle since they work at room temperature. Reactive dyes are best used at home or at art studios.

Disperse dyes:

These dyes are specifically used to dye cellulose acetate. They are used along with dispersing agents. They are ground into a powder and used as a paste. They can also be used to dye nylon, cellulose tri-acetate and acrylic fibres. Their main use, however, is to treat polyester. A dyeing temperature of 133 degrees Centigrade (266 degrees Fahrenheit) is required and a pressurised dye bath is used. The very fine particle size, provides a large surface area which helps to dissolve and allow uptake by the fibre. The dyeing rate can be influenced by the dispersing agent used in grinding.

Azoic Dyeing: This is a technique in which an Azo dye, an insoluble dye is formed onto or within the fibre. This is achieved by the combined use of diazoic and coupling components. Appropriate bath adjustments with the reaction of the two components will result in an insoluble azo dye. This is a unique dye as the final colour is dependent upon the choice of the diazoic and coupling components. The use of this technique for dying cotton is declining due to the toxic nature of the chemicals used.

Sulphur dyes:

These dyes are used in cotton to give dark colours. This dye is made by heating the fibre in a solution of organic compound, a nitrophenol a nitrophenol derivative and a polysulphide. The sulphide produces a dark colour. Sulphide Dark black is a popular dye selling widely, though it does not have a well-defined chemical structure.

Theory of Dyeing.

The properties attributing to the expression of dyes are the nature of colour (as revealed by the reflection of light on the cotton fibre); polychromatic light or monochromatic light, nature of dyeing, conditions of dyeing, importance of investigation and simple and compound dyeing.

The essence of theory of dyeing revolves around the fact why and how the desired reflecting surface is obtained or by what we really mean as fixation of colour on various fibres and fabrics.

But this has become a matter of controversy over a period of time. It was thought by some chemists that there is a true chemical combination between the colouring matter and the fibre and this occurs in equivalent proportions. Others believed that the combinations arise from a special action in which the usual chemical proportions equivalent are not obtained by the catalytic action of the fibres. While some were of the opinion that chemical action had little to do with the matters and colours are fixed upon or within the surface of the bodies by molecular attraction alone; others were vehement in their belief that the absorption is altogether mechanical and the colouring matter is absorbed into the pores and cells of the fibres and held there simply as a pigment.

After all these debates, three theories viz., Mechanical theory, Chemical theory and Chemico-Mechanical theory were propounded. These have been described in detail in the book, 'Textile Fibres' by J.F. Barker in the 1920s.

Recent Research Trends

After a decade of research, Eric Leite Pados and his group has recently come up with new findings that natural red pigments like betalains in beetroots can be changed to blue by changing the molecular structure of carbon bonds. This exciting new research could open the door for the advent of new pseudo-synthetic dyes, that have been obtained by changing the pathways of the natural pigment processes.

Knowledge of natural dyes and research in search for new dyes could help evolve a new range of textile fibres by going back and referring to ancient dyeing history. This will enable the dyeing profession to continue to live its heritage and preserving the diverse ethnicities of the world.

Some of the books that give an exhaustive and detailed account of ancient dyeing history are as follows: 'Textile Fibres' by Mathews (1929), 'The Structure of Cotton Fibre ' by Bowman(1908) and 'Textile Fibres ' by J.F. Barker.

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