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2. Recent Advances in Textile Dyeing and Printing

Tanvi Kumari, Dr. Divya Rani Singh

Research Scholar, Professor,
Department of Home Science,
DDU Gorakhpur University,
Gorakhpur, Uttar Pradesh.

Abstract:

Dyeing and printing is the process of coloring any textile material. Now a day's textile have gone under the chemical processing because of the outcome. But through developments in textile dyeing and printing the revolutionary change is desirable. The productivity, beauty and sophistication of textile are increased. Through these advancements eliminate the wastage of dye liquor and printing paste. These researches are in both natural and synthetic ways of dyeing & printing so the commercial use of these methods are highly acceptable & productive.

Keywords: *Synthetic dye, Plasma technique, Ultrasonic radiation, Eco printing, Nano-Keratin.*

2.1 Introduction:

Human's likeness towards colors is not only from today, but from centuries. Along with the development of civilization, the work of manufacturing of clothes took place. The beauty and attractiveness of clothes increases with the use of colors. Even before the advent of the art of making clothes, humans used to decorate their body. Even today nail polish in the fingers of the hands, mehndi or aalta in the feet, Sindoor & Bindi on forehead and colorful bangles are worn on the wrist.

Colors have a profound effect on our emotions. Some colors are hot, while some colors are cold; red, yellow and orange are hot. They represent happiness, joy, gaiety and ecstasy and are consider suitable for auspicious works. These colors are meant to be symbols of happiness. Blue, green and violet colors are cool and indicate happiness, coolness, peace and contentment. White color signifies purity. Depression, sadness and a feeling of rebellion are associated with the color black.

In our India white & black clothes are not considered good for married women because it is considered an indicator of legitimacy. The clothes of colors which gives the impression of coolness and contentment in the summer and colors that gives the impression of warmth in the winter should be chosen. Colors also have affinity for emotions. Bright colors show a cheap gesture. Whereas dark colors give seriousness. Depression arises in the mine due to dirty mind. In ancient times, colors were made from indigo, henna, and leaves of harsingar and flower of palash. They were also used to dye and print clothes. India's position in the manufacture of colors was leading.

The art of dyeing was taken from India itself to the whole world. With the development of civilization and the increasing love and affection for human colors, many colors were made by combining two more colors.

In this way the creation of colors continued to develop. Now there was not only development in the manufacture of colors, but also fills the mind with happiness, joy and gaiety and gives pleasure to the eyes.

In this way colors give log lasting beauty to the clothes. On the same way coloring stuffs which are used in dyeing & printing of textile, have some quality like the person have knowledge about affinity of dyes & their fastness properties, have efficacious handling to fabricate hues & shades of dyes.

Every coloring stuff is not fit for every fiber so it is needed to treat with some chemicals for appropriate outcomes. Dye stuffs are labeled according to their implementation and chemical structure and are produced by a group of atoms known as chromophores which are accountable for the color of dye.

These chromophores have centers that are placed on multiple functional groups like azo, anthraquinone, methane, aril-methane, nitro, carbonyl & others. Textile can be dyed & printed with both natural & synthetic process dyes are applied on material through the natural things (dyes & mordents) directly.

But in the synthetic process, synthetic dyes are applied on the fabric directly. In these processes there have been some developments which will discuss in this chapter.

2.2 Recent Advances in Textile Dyeing:

2.2.1 Natural Dyeing:

Now a day's people are aware towards natural dyes because of its non-toxic & ecofriendly nature. However they have some limitation and very stretching to apply. They have some inherent demerits like less or no absorption nature onto textile. They also need mordents fixer and other chemical to apply enhance their absorbency. They also restricted their potential in large scale production. So for the dye uptake on textile plasma treatment is introduced with natural dyes.

2.2.2 Synthetic Dyeing:

Synthetic dyes are biological compounds which are used for transferring color to paper, textile leather etc. for an appropriate & permanent fashion. These colors are affordable, fixed, permanent, and bright and attract material to be fixed on it. In dyeing Industries these dyes are used widely because of above reasons. But in the switch technology, from hand to water to steam power and then to electricity, radically changed the textile firms, its product marketability and its practicality. Now it's time for one more change! Plasma technology is assured to change the conception of textile wet processing, as we all know Innovation never ends.

a. Application of Plasma Treatment on Textile:

- **What is Plasma?** Basically plasma is an ionized gas with essentially equal density of electrical (negative & positive) charges. And now a days it calls gas plasma because electrical charges are being generated by a gas which consists a mixture of positive & negative ions, free radicals, electrons ultraviolet radiation and various electronically excited molecules. So according to gas or gases this treatment differs in nature for example air, argon ammonia etc.

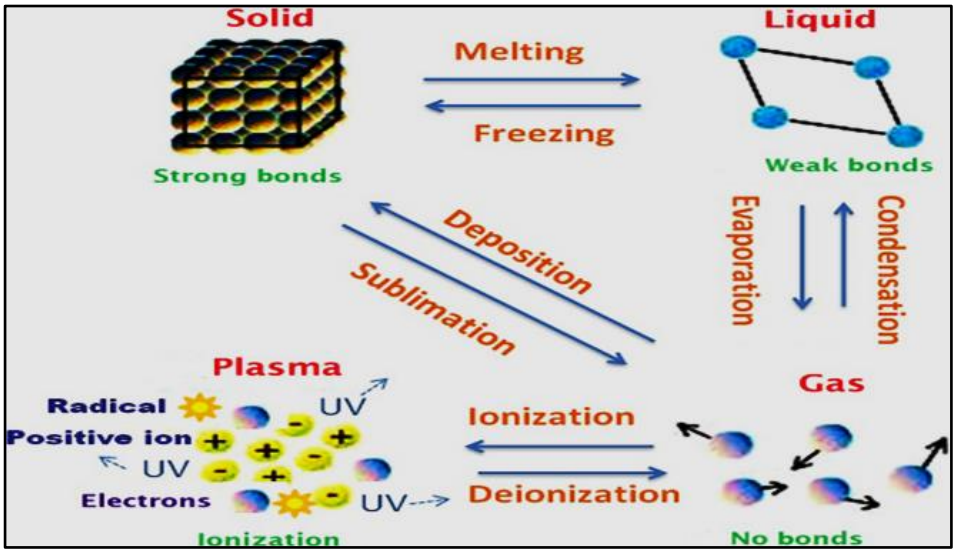

Figure 2.1: Plasma

- **Pretreatment of textile materials:** For this treatment, it is necessary to remove sizing (starch). Sizes are removed by the wet processing as done before dyeing & finishing. Due to this weight loss plasma treated fabric increase with exposure time of less than 5 min.
- **Implementation of Plasma treatment for dyeing:**

  - **Application on Cotton:** Application of plasma treatment on cotton in existence of air or argon gas expand its water absorbency. According to a report the reaction of air and oxygen plasma on the rate and the range of dye uptake of Chloramine Fast Red K on cotton print cloth is increased both the rate of dye and the dye uptake. Oxygen treatment is better than air plasma treatment (Guglani 2008). By the implementation of plasma treatment on cotton fiber is modified its surface and changes its dye ability against natural dyes.
  - **Application on Wool:** It is asserted that the wool fiber treated with plasma treatment intensify the dye uptake, no any remarkable effect is perceived on the absorption on the hydrophobic dyes. On the other hand the absorption of hydrophilic dyes on plasma treated wool fabric is more captivated (Naebe *et. al*. 2010). So the material treated with plasma is more essential on the absorption and the fastness of the dyes with excellent water solubility as compared to the dyes with lesser water solubility.

For example the wool is dyed by berberine natural dye with atmospheric-pressure air plasma is amplified the dye ability. And the intensity of the color is upgraded by expand the plasma treatment time betwixt 1 to 3 min (Haji & Shoushtari 2011).

- **Application on Silk:** In the natural dyeing on silk fabric, mordents are required through the traditional way. According to some reports, after the plasma treatment, the dye ability of silk is improved and the use of mordents is avoided (Haji et. al. 2020). Oxygen and argon low pressure plasma is pretreated on silk upgrade the capacity of absorption with lac dye, in both the treatments, the silk ample treated with argon plasma is more effective than oxygen plasma, which might be due to electrostatic effect by different plasma treatment (Boonla & saikrasun 2013). And the upgradation of dye ability of natural dye extracted from Sambucus Ebulus L fruit by the treatment of low pressure oxygen plasma for 1 – 5 min on silk sample. And as the duration of plasma treatment is increased and the strength of dye is also improved (Dayioglu et. al. 2015).
- **Application on Synthetic Fibers:** Plasma technology creates polar groups (a chemical compound) which beget etching of the fibers. The application of situ polymerization of acrylic acid is implemented on polyester, polypropylene and polyamide fabric in order to improve dye ability against basic dye (Guglani 2008). This mechanism could be held forth by using various monomers to enhance the affinity of these fibers against various dyes. Another study expressed that the dye ability of polyester fabric with natural dyes (henna & madder) and synthetic dyes (basic, acid & disperse dyes) is improved through air DBD plasma treatment. The amelioration of natural dyes was more appreciable than for synthetic dyes (Shahidi et. al. 2015).

b. Application of Ultrasonic Assisted Dyeing:

- **What is Ultrasonic Radiation:** All these are the reaction of waves. There is an abbreviation during every rotation of wave. As the absorption of ultrasonic wave in liquid structure, the occurrence of cavitation takes place, which is the swap wave formation, oscillation and collapse of small bubbles. During the rarefaction of part of the fixed cycle, the frac gas molecules acts as nuclei to form cavities, which expand comparatively slowly up to 0.1 cm in diameter and then quickly fall off during the compression part of cycle.
- **Dyeing through ultrasonic radiation:** Dyeing of textile by the use of ultrasound can be discussed that the cavitation can make free entangled gases from fluid or porous material like dye bath & textiles etc. The effect of ultrasound on dyeing is discussed by three way effect:

  - **Dispersion:** The separation of micelles & high molecular weight collections into uniform scattering in dyebath.
  - **Degassing:** Removal (Solvate or trapped air or gases molecules from the capillaries of fiber and interval at the cross over point of the fiber into fluid and separate cavitation)
  - **Diffusion:** By piercing of insulating layer which covers the fiber dyes are expedited the rate of scattering inside it.

Ultrasound is effective medium of mechanical agitation for water soluble dyes but for the pigment dye which is not soluble in water ultrasound is furnished the scattering and penetration which is not available in conventional method.

- **Microwave Dyeing**: This dye procedure is worked only the dielectric and thermal properties. The dielectric property connects only to the intrinsic electrical properties that influence the dyeing procedure by dipolar cycle of the dye and affect the microwave upon the dipoles. Vibrational energy of dye molecules and water molecules is influenced by microwave. Ionic conduction is used for heating mechanism in it which is a kind of resistance heating. It depends on the forwarding ions by the dye solution, and the result is in crash of dye molecules with fiber molecules.

c. Electrochemical Dyeing:

This dye technique is especially for the vat and Sulphur dyes because these dyes are insoluble in water. So it is necessary to convert in water soluble dye by some chemical methods like reducing agents & alkali. Various reducing agents apply for Sulphur & vat dyes are explained with prominence on the emanate technique of electro chemical reduction. Sodium hydro-sulphate or sodium dye thionate is commonly used for reducing vat dye. According to Dye star Company, in this procedure an electric current is used in place of chemical reducing agents, which gives many economical, technical and ecological benefits.

There are two methods to use electrochemical dyeing:

- **Direct Electrochemical Dyeing**: In this method dye & electrode are contacted for directly reducing of organic dyestuff. Whereas in the conventional methods, dyestuff is partially reduced by chemical reducing agents. But in electrochemical process complete reduction of dyestuff is attained which improved stability of the reduced dye.
- **Indirect Electrochemical Dyeing:** In this method dye is not reduced directly at the electrodes. The dyestuff is reduced by a reducing agent in a conventional manner and that agent gets oxidize after dye reduction. The cathode surface eventually reduced the oxidized reducing agent, which is then later accessible for dye reduction. During the dye operation this cycle is repeated.

d. Super Critical Carbon Dioxide (CO_2):

Basically in any dyeing process water is a medium of solvent because it is low cost and easily available. But the problem is remaining dyestuff liquor after dyeing which polluting the environment and additional pollution of water waste. So in supercritical CO_2 method CO_2, H_2O and propane is the prominent substances. In this method low pressure & temperature are necessary to change CO_2 gas into supercritical fluid. In this state (Supercritical) CO_2 shows very low viscosity & surface tension properties. In this dye system three things are needed which are dye stuff, supercritical fluid and textile material. The supercritical fluid dissolved dyestuff and transferred to & absorbed by the fiber.

2.3 Recent Advances in Textile Printing:

The selected fabrics are finished by the printing process. When it is dyed with one colour, it is called dyeing process. It is called dyeing process. But in the printing process the color is transferred on the fabric according to different shapes and designs.

Thousands of years before Christ, printing work was done on cloth, but then these works were done only hand. Samples were printed by plants residues, bottle caps etc. But the carved residues made on trees or plants were destroyed after some time and it became difficult to find the remaining portions of the same specimen again. Therefore tireless efforts of human beings removed this difficulty. Now they started preparing samples from the engraved on the wooden block.

Design engraved stamps are dipped in a semi-liquid paste of color and applied over the garment. Now a day's printing work is done by hand and machine both. Printing is done by hand takes a lot of time, labor and money. But printing is done by machine for higher production with saving time, power and money. During the last few decades, a lot of researches have been done in textile printing technology, especially in printing machines and post treatment of printing. Some advances in textile printing is discussed below:

2.3.1 Inkjet Printing:

Inkjet printing is an emerging technique which apply little amount of printing paste to a particular area of textile. This style of printing is a non-impact form of printing. Drops of the dye are protruded on the surface for printing. The application of inkjet printing is limited to computer offices, hard copy of textile design and printing on pile & carpet fabric. But now this printing technique is also developed for textile substrate in the developed countries.

In this printing machine, the substrate is being pressured during the transfer of ink. This method is non-contact method of printing in which the ink is transferred without any physical contact between the substrate and the ink dispenser. The multi layered deposition, high- accuracy, high -speed patterned and high resolution is enabled by non-contact printing.

2.3.2 Screen Printing:

Screen printing is an ancient printing method to print any textile substrate. Later it is converted in digital fabric printing method. In the fully automatic flat screen printing all the color is printed with improved high speed printing. On average, this machine can hold 16 or more colors in one time. Some system developments are discussed below:

- **Adhesive System**: In this system blanket using on rollers is coated through water-based glue or sticky permanent or semi-permanent adhesive. And this adhesive layer is transferred on the fabric surface by heating process.
- **Squeeze System**: In this system a pair of parallel double blade squeeze (rubber blade squeeze) or magnetic rod squeeze is used for printing.

2.3.3 Rotary Screen Printing Machine:

In this printing technique a cylindrical screen is used and continuous rotate to print the fabric. The printing paste is loaded in screen and a stationary squeeze is forced the color throughout the design area to print the fabric. All these processes are moving continuously and print a large amount of material.

2.3.4 Transfer Printing:

In this printing process color is transferred onto the fabric for a short period of time at very high temperature & pressure without any image distortion. Through this process a large number of fabric is produced. Approx. all type of transfer printing heat & pressure are applied for printing fabric.

2.3.5 Digital Printing:

This printing technique is printed all digital based images. Printing plate is not required for this printing. It is printed on canvas, paper, fabric, synthetics & other substrates with the help of digital files like PDFs, JPGs, etc.

2.3.6 Printing with Natural Pigments:

There are many varieties of plants, animal and microorganism which produced pigments. In nature, production of color /pigment is obtained from fungi, algae, bacteria & small crustaceans. Microorganism is produced many pigments like melanins, carotenoids, quinines, flavins, prodigiosins and more effective monascins, violacin or indigo (Dufosse 2009).

In all these pigments fungus *A. alternate* can be used as a safe dye on cotton fabric. The standardization of fermentation conditions can be developed at large scale level in eco-friendly manner. These pigments can be used with any natural gum and produced good printing material (Sagarika 2015).

2.3.7 Pigment Printing with Nano-Keratin Binder:

Pigment printing is old & easiest method of printing. Approx. 80 % of the printed materials are done by pigment printing because of its advantages like flexibility, ease of printing also (Iqbal 2015). Keratin is a high relative molecular weight natural polymer. According to a research, keratin (nano-sized) is developed from economically renewable natural resources by easy & ecofriendly process. The developed nano-keratin is used as a binder in pigment printing of viscose, polyester, poly-acrylic, viscose/polyester & viscose/poly-acrylic fabric for put back the industrially available binder which is very high in cost and unsafe for the environment (Taleb *et. al.* 2018).

2.3.8 Eco Printing with Laser Technology:

Recently, the researchers are developed an excellent idea which is Heat-Induces Eco-printing (HIEP) on paper without the use of toner. This technology is reduced the pollution and uses the yellowish discoloration of plant fiber. A new silk laser eco-printing (SLEP) technology is hinged through heat-induced without ink eco printing has developed. Firstly silk fabric surface is treated with carbonization process. The laser energy with high density is used, so fibrous protein of irradiated silk fabric melt rapidly and carbonized at high temperature (chen et. al. 2016).

2.4 Conclusion:

Textile dyeing and printing methods and technologies have been advanced so the time and cost both can be saved. Both dyeing and printing are becoming more effective, easier, environmental friendly and cost friendly.

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