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DYES AND THEIR IMPORTANCE : A REVIEW

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ABSTRACT

The global market for pigments and dyes is forecast to reach 9.9 million tons and $26.53 billion by the year 2017, driven by the growth in key end-use industries. Before synthetic dyes and pigments were discovered, limited number of natural colorant has been obtained from plants, animals and minerals. The classification of colorants has become mandatory due to huge increase in kind and number of colorants. For this reason, colorants are classified based on their structure, source, color, solubility and application methods. In this chapter, dyes will be investigated in two different groups as accordance with chemical structures and

application methods. The basic classification groups were determined as azo, anthraquinone, indigo, phthalocyanine, sulfur, nitro and nitroso dyes by considering their chemical structures. According to application method, they were grouped as reactive, disperse, acid, basic, direct, and vat dyes. However, the classification of pigments as organic and inorganic pigments is also regarded as an appropriate way.

Keywords : Dye, Classification , color, synthetic, natural

INTRODUCTION

Dyes (D)

Dyes are organic colored compounds imparting the color to substrates like hair, drugs, paints, paper, wax etc.

These are colored because absorbs visible light at certain wavelength. All colored compounds are not dyes but dyes are colored.

Basic Requirement for Dyes:

1. Dyes are usually soluble in water.
2. Ability to impart the color.
3. Ability to standing with washing, drying, cleaning or exposure to light.
4. They should be chemically stable.
5. Dyes should be absorbed and retained to material to be dyed.

Autochrome and chromophore-functional groupings are present in dyes, which are organic compounds. Their structure is unique, and they bond in a certain way (www.xtremePaper.com). Dyes exhibit characteristics such as color, solubility in water, abilit to absorb and hold fiber, ability to expose to light, ability to withstand dry cleaning, and ability to withstand washing. According to their source, structure, and functional groups, dyes can be divided into a number of different types.

Classification of dyes

Natural Dyes

Natural dyes are those that are derived from plants, minerals, invertebrates, etc.These dyes can be made from a variety of plant parts, including roots, berries, bark, leaves, and wood. Fungi and lichens are also sources of dyes.Dyes are obtained from plants like leaves, root, bark etc. and animals are calledNatural Dyes.For example Alizarine (obtained from the Madder plant), Blue dye (Indigo), Red dye or Carmine red (Carmic acid) obtained from coccus cacti, and cochineal (obtained from Insects).Natural dyes are few in number and have limited shades/colors.

Synthetic Dyes (artificially man-made dyes)

The synthetic dyes prepared in the laboratory have huge numbers/Shades. The starting material for synthetic dyes can be obtained from coal tar distillation. Artificial dyes (Synthetic dyes),These are dyes created in a lab or manufactured for usage in various industries. Examples include dyes that are acidic, azo, basic, mordant, etc (Barni et al., 1991).

Natural and synthetic dyes are the two main groups of colors used in textile dyeing. Natural dyes have been used to color food materials, leather, and textiles including wool, silk, and cotton since prehistoric times. Due to the rising environmental consciousness to avoid some hazardous synthetic dyes, the use of non-allergic, non-toxic, and environmentally friendly natural dyes on textiles has assumed major relevance. Currently, synthetic compounds are used to dye textile textiles, and because they are non-biodegradable and carcinogenic, they contribute to water contamination as well as issues with waste management. Natural dye can be used to address these issues. The majority of natural dyes—also referred to as natural pigments—come from plant roots, stems, leaves, flowers, fruits, animals, or naturally colored ores. Colorants used in natural dyes are derived from plants, invertebrates, insects, fungi, or minerals. Vegetable dyes, the majority of which are natural, are mostly derived from various plant parts, including roots, stems, seeds, barks, leaves, and wood. Insects, snails, fungi, and other biological sources are also available. Before chemical dyeing, natural sources accounted for the majority of textile dye supplies.

To counter the harm that synthetic dyes do to the environment, many commercial dyers have recently begun employing natural dyes. Most of the plants used to extract dyes are considered medicinal, and recent research has shown that several of these plants have an antibacterial impact. The antibacterial qualities of these plant dyes help the textile materials last longer when they are applied to textiles. Color has played a significant impact in the emergence of various human cultures all over the world. Color has a big impact on our lives, our wardrobes, and the furniture in our houses. Natural colors are determined to be environmentally beneficial and to have no carcinogenic or allergy effects when compared to synthetic dyes.

History of natural dyes

Around 2600 BC, the first natural dye was discovered. To dye skin, jewelry, and clothing in the past, natural pigments were combined with water and oil. In the past, caverns in areas like Spain were painted with natural dyes. According to data, herbs, barks, and insects were used as dyes in China about 5000 years ago. A two-step procedure for making green dye was invented by Navajo textile artist Nona bah Gorman Bryan. The Churro wool yarn is first dyed yellow with Artemisia tridentata, a sage plant, and then given a black dye bath afterward. Bright pink pigment was found in rocks recovered from far beneath the Sahara in Africa by the research team. The pigment's age was determined to be 1.1 billion years.

Natural Dye

Natural dyes are colorants derived from organic materials. Up to the middle of the nineteenth century, natural dyes were utilized for all kinds of textile dyeing and printing. The introduction of synthetic dyes led to a decrease in the usage of natural dyes, despite the fact that they were more affordable and had superior fastness properties. However, the resurgence of natural dyes is due to increased consumer knowledge of the negative effects of synthetic dyes, global environmental concern, and strict environmental laws. The beauty of natural colors is breathtaking. Different expectations can be made of the coloring material that is collected from the roots, stems, leaves, or flowers of different plants.

Advantages of natural dyes

Natural dyes like turmeric have anti-microbial properties, protecting the fabrics and wearers from microbial attack. Some natural dyes have mosquito repellent and flame resistant properties. Natural dyes are environmentally friendly because they are extracted from natural sources and produce soft, calming colors. They also offer excellent protection from UV rays.

• **Minimal Environmental Impact -** Because natural dyes are derived from sources that are not damaging to the environment, consumers find them to be quite appealing. Natural colors are biodegradable, and their disposal doesn't harm the environment.

Natural colors are obtained from renewable resources that can be used without causing environmental harm.

• **Safe -** When swallowed, some natural colors, including the carmine found in lipsticks, do not hurt or pose health risks.

Disadvantages of natural dyes

Natural dyes have a number of drawbacks, including: difficulty in storing, time-consuming dye extraction, difficulty in reproducing the same color shade, fading of created color due to impurities in natural dyes, and seasonal availability.

• It is challenging to standardize the natural dyeing procedure

Classification of natural dyes

Natural dyes are classified into three types based on the source of origin namely vegetable dyes, animal dyes, and mineral dyes.

Plant dyes

Inadvertently staining clothing with fruit or plant fluids led to the discovery of the earliest dyes, which were of botanical origin. Plants can produce vegetable dyes in a variety of ways, including through the production of leaves, flowers, fruits, pods, bark, etc. These vegetable dyes can be used either directly or in conjunction with other mordants.

Henna: The dried leaves of the Henna plant, Lawsoniainermis, are used to make the dye. It results in orange-yellow color. It works well for dying silk and woolen fabrics.

Blue dye indigo is referred to as the "monarch of all-natural dyestuffs." It gives off a blue tint. It is derived from Indigofera tinctoria, a leguminous plant, and its leaves. It works well for dying wool and cotton.

Indian Madder: It causes various colors of red to appear on textiles. Fabrics made of cotton and wool can be dyed with it. It is taken out of Rubia tinctoria roots.

Turmeric: It causes various yellow hues to appear on textiles. It works well for coloring wool, silk, and cotton. The turmeric plant's ground root (rhizome) is used to make the yellow dye (Curcuma longa).

Marigold: It is made from the flower of the calendula officinalis plant, which has yellow or orange petals. It works well for coloring wool and silk fibers.

Tea: To extract the dye, tea leaves (Camellia sinensis) or tea powder are employed. It generates various brown hues.

Onion: The onion's outermost skin or peel is used to extract the colour (Allium cepa). If dried properly, onion skins can be used for a year.

Senegalia catechu: The resin is used to extract the dye. the plant material that comes from acacia trees. Brown hues are produced.

Old fustic, also known as yellowwood, is made from the heartwood of the dyer's mulberry, a sizable tropical American tree (Chlorophora tinctoria, or Maclura tinctoria), which belongs to the mulberry family, Moraceae

The dye produces yellows on wool mordanted (fixed) with chromium salts.

Animal dyes

According to the study, the red-mouthed rock shell collapse was caused by the sea's warming, which was one of the main sources of Tyrian purple. The most regal and revered of all ancient dyes, Phoenician purples and BIBLICAL BLUES were made from Levantine sea snails of the Muricidae family. It's possible that these mollusks were used to make the royal purple color.

Cochineal dye

The dried bodies of female red bugs are used to make cochineal dye (Dactylopius coccus). With mordants like aluminum and tin oxide, it creates the colors crimson and scarlet. The majority of the time, this dye was used to color wool and silk. These colors have exceptional fastness characteristics.

Tyrian Purple

The Mediterranean Sea's sea snails are used to make this color. Because the amount of dye produced was so small, it was also exceedingly expensive. As a result, it is known as Royal purple.

lac dye

The liquid released by the lac bug (Lauiferlacca), which inhabits the twigs of various types of plants including banyan trees, is used to make this color.This dye is extracted from the sea snails found in the Mediterranean Sea. The amount of dye produced was very limited and therefore very expensive. Hence, it is called Royal purple.

Mineral dyes

Mineral dyes are dyes that have been derived from mineral sources. Chrome green is derived from a chromium and oxygen molecule, Chrome red is derived from a chrome and lead compound, Chrome yellow is derived from a chromic acid and lead compound, while Prussian blue is derived from an iron and cyanide complex. The term "natural dye," which encompasses all colors made from natural materials, is more accurate because minerals are utilized to fix or improve the fastness of vegetable dye. Additionally, some minerals are employed to provide a coloring substance.

Synthetic Dyes

Direct or substantive dyes (soluble in water)

These colors were aqueously applied straight to the cloth. It involves soaking the fabric in an aqueous dye solution, taking it out, wiping off any extra solution, and then letting it air dry. Strongly polar direct dyes, like wool, are used to colorize polar or moderately polar materials (e.g., cotton, rayon). Since common salt is used throughout the dyeing process, some dyes, like Congo red, are sometimes referred to as salt dyes.

These dyes are further subdivided into two groups:

Acidic dyes

Acidic dyes include nitro naphthols such acid orange-7 (orange-II), picric acid, and martius yellow. These dyes, which are of a proteinous type like wool and silk, come forth as a result of the interaction between the polar acidic group of the dye and the basic (-NH2) group of the fiber.For example, orange-II .

Basic dyes

These are the cationic dyes with basic groups like -NH2, -NHR, and -NR2, as well as their salts (mostly in the form of HCl and ZnCl2 salts). These are employed for immediately dying animal fibers, however cotton (vegetable fibers) is first moderated with tannin. Malachite green, magenta, para-rosaniline, etc. are a few examples. Aniline yellow and butter yellow, two azo dyes having a -NH2 group, are now also regarded as basic dyes because of their fundamental makeup.

Vat dyes (insoluble in water)"Vat means vessel"

These dyes are sprayed just onto the fabric. These work best with cotton and rayon; silk and wool cannot be utilized. In this instance, the dyeing is done continuously in a big container called a vat. These colors are known as vat dyes for this reason. For instance, Tyrian purple and Indigo blue (6,6'-dibromoindigo).

These dyes are insoluble in water and are first reduced (also known as "vatting") in an alkaline medium, where they are then transformed into a form that is soluble in water (leuco compound).

Mordant dyes (or indirect or adjective dyes) (insoluble in water)

These dyes cannot be dissolved in water, so a third ingredient is added to bond the dye to the fiber. These dyes are referred to as mordant dyes, as is the third substance. Fiber is dipped in mordant, dried, and then dipped once more into the dye solution during the dyeing process. The mordant and dye combine to create a complex that is then placed on the fiber, giving it a lasting color. An acid mordant, such as tannic acid, is used for basic dyes while a basic mordant, such as metal salts Fe(OH)3 and Al(OH)3, is used for acid dyes. An illustration of a mordant dye is alizarin. When combined with different materials, it produces various hues. With Al and Sn salts, it produces a red tint with brownish red undertones.

Azo dyes (or ingrain or developed dyes) (insoluble in water)

These are put on the fiber right away. The procedure involves low-temperature diazotization and coupling reaction on the fiber itself. The fabric is first soaked in an alkaline phenol solution, dried, and then submerged in a cold diazonium salt solution. On the fiber itself, the azo dye is created. Due to the fact that these dyes, also known as developed dyes, produced inside the cloth at a low temperature, they are also referred to as Ice colors.An example of such a produced dye is para-red. These dyes can also be created in reverse. The fabric is soaked in an alkaline solution of phenol after being impregnated with an amine, which is subsequently diazotized and developed. The term "ingrain dye" is also used to describe such dye.

Disperse dyes (insoluble in water)

Although these colors are insoluble in water, they can dissolve some synthetic fibers. Disperse dyes are typically used in the presence of a solubilizing agent, such as phenol, cresol, or benzoic acid, as a dispersion of finely divided dye in a soap solution. High heat and pressures are used to carry out the absorption into the fiber. Acetate rayons, Dacron, Nylon, and other synthetic fibers are dyed using disperse dyes.Examples include Celliton Fast Blue B and Celliton Fast Pink B, both of which contain 1,4-N,N'-dimethylaminoanthraquinone.

Importance

Significance of dyes effect on surfactants

Surfactants are used in a variety of industrial settings, including the dye industry because they can wet materials and aid in the dispersion of dyes, particularly those that are poorly soluble. By wetting and leveling or dispersing low solubility dyes, surfactants help with dyeing. Below the CMC, a true ion association complex forms between the ionic surfactant and dye. Interaction occurs due to the opposing charge in surfactant and dye (Hautala et al., 1973**)**

Dye – surfactants interaction

When dying textile fibers, the interactions between surfactants and dyes are extremely important from a practical standpoint. Surfactants perform a variety of functions in the dyebath. They can delay dye adsorption, enhance the solubility of less soluble dyes, and act as wetting and antifoaming agents. The latter is especially important when looking for a textile substrate with consistent coloration. Recently, surfactant mixtures have been used as leveling agents. Ionic and nonionic surfactants are combined to form mixtures, with nonionic surfactant concentrations above the critical micelle concentration (c.m.c.) and ionic surfactant concentrations falling below the c.m.c. Ionic surfactants can function as a substrate for fiber or dye [Datyner., 1983]. It is possible for dye-surfactant complexes to develop when a surfactant has a charge that is opposite to that of the dye. As a result, a textile substrate can be colored uniformly at low temperatures by reducing dye adsorption onto textile fibers. Insufficient bath exhaustion could happen if the strength of complexes is too strong to prevent them from disintegrating as the temperature rises. When an ionic surfactant with the opposite charge is added to an ionic dye solution, it frequently results in the development of insoluble complexes, which take the form of precipitates. The ionic surfactant can be added in amounts greater than stoichiometric amounts to prevent precipitation, or nonorionic surfactant concentration higher than the c.m.c. of the solution.

The interactions between dye and surfactant in aqueous solutions have been the subject of several investigations due to their enormous technological relevance. By allowing for a more rational application of surfactants as leveling agents in dyebaths, understanding how they work can considerably aid in the creation of dyeing processes that are more acceptable from a technological, ecological, and economic standpoint. In the framework of our study on the intermolecular interactions taking place between dyes and surfactants in dyebaths, the impacts of different factions on the strength and stability of the dye-surfactant complexes are detailed.

CONCLUSION

Hence this review presents gives the classification of dyes by dye class, their applications, Principles, follow the preparation of substrates for dyeing and the thermodynamics of dyeing systems. Each dye class is described in detail giving more specific information regarding the chemistry of the dye class and the most common mode of application.

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