MODULE 2 CLASSIFICATION OF DYES AND FIBRES

UNIT 1 CLASSIFICATION OF DYES

CONTENTS

1.0 INTRODUCTION

A dye can generally be described as a coloured substance that has an affinity to the substrate to which it is being applied. At the very basic level the use of colour in identifying individual components of tissue sections can be accomplished primarily with dyes. Although there are other means, dyes are however, the largest groups that can easily be manipulated to our liking. Dyes are applied to numerous substrates for example to textiles, leather, plastic, paper in liquid form.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- define what a dye is
- describe the several ways for classification of dyes
- Identify each class of dye with the very unique chemistry, structure and particular way of bonding.

3.0 HOW TO STUDY THIS UNIT

1. You are expected to read carefully, through this unit at least twice before attempting to answer the self-assessment questions or the tutor marked assignments.
2. Do not look at the solution given at the end of the unit until you are satisfied that you have done your best to get all the answers.
3. Share your difficulties with your course mates, facilitators and by consulting other relevant materials particularly the internet.
4. Note that if you follow the instructions you will feel self fulfilled that you have achieved the aim of studying this unit. This should stimulate you to do better.

4.0 MAIN CONTENT

4.1 Definition of Dyes

By definition dyes can be said to be coloured, ionizing and aromatic organic compounds which show an affinity towards the substrate to which it is being applied. It is generally applied in a solution that is aqueous. Dyes may also require a mordant to improve the fastness of the dye on the material on which it is applied. A mordant is an element which aids the chemical reaction that takes place between the dye and the fiber so that the dye is absorbed.

4.2 Different Classification of Dyes

There are several ways for classification of dyes. It should be noted that each class of dye has a very unique chemistry, structure and particular way of bonding. While some dyes can react chemically with the substrates forming strong bonds in the process, others can be held by physical forces. Some of the prominent ways of classification is given hereunder.

a. Organic/Inorganic
b. Natural/Synthetic
c. By area and method of application
d. Chemical classification- Based on the nature of their respective chromophores.
e. By nature of the Electronic Excitation (i.e. energy transfer colourants, absorption colourants and fluorescent colourants).
f. According to the dyeing methods
   - Anionic (for Protein fibre)
   - Direct (Cellulose)

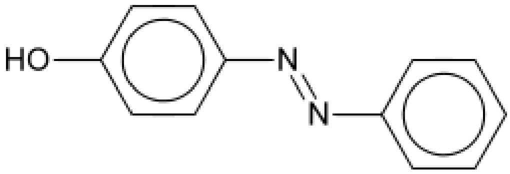
- Disperse (Polyamide fibres)

4.2.1Chemical Classification of Dyes

Table 1.1: Chemical Classification of Dyes

Group	Uses
Acridine dyes, derivatives of acridine>C=N- and>C=C	Textiles, leather
Anthraquinone dyes, derivatives of anthraquinone>C=O and >C=C	Textiles
Arylmethane dyes Diarylmethane dyes, based on diphenyl methane Triarylmethane dyes, based on triphenyl methane	
Azo dyes, based on a -N=N- azo structure	
Cyanine dyes, derivatives of phthalocyanine	
Diazonium dyes, based on diazonium salts	
Nitro dyes, based on the -NO_2 nitro functional group	
Nitroso dyes, are based on a -N=O nitroso functional	
Phthalocyanine dyes, derivatives of phthalocyanine>C=N	Paper
Quinone-imine dyes, derivatives of quinone	Wool and paper
Azin dyes Eurhodin dyes Safranin dyes, derivatives of safranin -C-N=C- -C-N-C	Leather and textile
Xanthene dyes, derived from xanthene -O-C_6H_4-0	Cotton, Silk and Wool
Indophenol dyes, derivatives of indophenol >C=N- and >C=O	Colour photography
Oxazin dyes, derivatives of oxazin -C-N=C =C-O-C=	Calico printing
Oxazone dyes, derivatives of oxazone	
Thiazin dyes, derivatives of thiazin	
Thiazole dyes, derivatives of thiazole>C=N-and -S-0=	Intermediate
Fluorene dyes, derivatives of fluorene	
Rhodamine dyes, derivatives of rhodamine	
Pyronin dyes	

Source: www.dyespigments.com



Yellow azo dye

SELF ASSESSMENT EXERCISE 1

i. List carefully the different means of classification of dyes
ii. Mention the functional groups present in the azo, thiazole, and the phthalocyanine types of dyes.

4.2.2 Industrial Classification of Dyes

Majority of the dyestuff is primarily consumed by the textile industry, so at this level a classification can be done according to their performances in the dyeing processes. Worldwide around 60% of the dyestuffs are based on azo dyes that are used in the textile finishing process. Major classes of dyes in textile finishing are as listed below;

(a) **Acid dyes**: They are water-solubleanionic dyes that are applied to fibers such as silk, wool, nylon and modified acrylic fibers using neutral to acid dye baths. Attachment to the fiber is attributed, at least partly, to salt formation between anionic groups in the dyes and cationic groups in the fiber. Acid dyes are not substantive to cellulosic fibers. Most synthetic food colors fall in this category.

(b) **Basic dyes**: These are water-soluble cationic dyes that are mainly applied to acrylic fibers, but find some use for wool and silk. Usually acetic acid is added to the dye bath to help the uptake of the dye onto the fiber. Basic dyes are also used in the colouration of paper.

(c) **Direct or substantive dyeing**: This is normally carried out in a neutral or slightly alkaline dye bath, at or near boiling point, with the addition of either sodium chloride (NaCl) or sodium sulfate (Na_2SO_4). Direct dyes are used on cotton, paper, leather, wool, silk and nylon. They are also used as pH indicators and as biological stains.

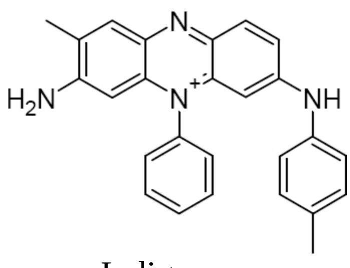
(d) **Mordant dyes**: This class of dye requires a mordant, which improves the fastness of the dye against water, light and perspiration. The choice of mordant is very important as different mordants can change the final color significantly. Most natural dyes are mordant dyes and there is therefore a large literature base describing dyeing techniques. The most important mordant dyes are the synthetic mordant dyes, or chrome dyes, used for wool; these comprise some 30% of dyes used for wool, and are especially useful for black and navy shades. The mordant, potassium dichromate, is applied as an after-treatment. It is important to note that many mordants, particularly those in the heavy metal category, can be hazardous to health and extreme care must be taken in using them.

(e) **Vat dyes**: They are essentially insoluble in water and incapable of dyeing fibres directly. However, reduction in alkaline liquor produces the water soluble alkalimetalsalt of the dye, which, in this leuco form, has an affinity for the textile fibre. Subsequent oxidation reforms the original insoluble dye. The colour of denim is due to indigo, the original vat dye.

(f) **Reactive dyes**: Theyutilisea chromophore attached to a substituent that is capable of directly reacting with the fibre substrate. The covalent bonds that attach reactive dye to natural fibers make them among the most permanent of dyes. "Cold" reactive dyes, such as Procion MX, Cibacron F, and Drimarene K, are very easy to use because they can be applied at room temperature. Reactive dyes are by far the best choice for dyeing cotton and other cellulose fibers at home or in the art studio.

4.2.3 Classification Based on the Source of Materials

(a) **Natural Dyes**: These are dyes obtained from natural sources – plant, animal or mineral. Roots, nuts and flowers that grow in the backyard are all sources of colouring pigments known as Natural Dyes. Many natural dyes had been earlier created and used at home long before the chemist created dyes in laboratories, there were dyers who extracted colours from flowers, leaves, roots, the outer and inner bark of trees as well as their heartwood. A common example is Indigo.



Indigo

(b) **Synthetic Dyes**: The first human-made (synthetic) organic dye, mauveine, was discovered by William Henry Perkin in 1856. Thousands of synthetic dyes have since been prepared. Synthetic dyes quickly replaced the traditional natural dyes. They cost less, they offered a vast range of new colours, and they imparted better properties upon the dyed materials.

4.2.4 Classification Based on Application

A number of other classes have also been established, based on application that includes the following:

(a) **Leather Dyes** – Used for leather.
(b) **Oxidation Dyes** – Used mainly for hair
(c) **Optical Brighteners** – Used primarily for textile fibres and paper.
(d) **Solvent Dyes** – For application in wood staining and production of coloured lacquers, solvent inks, waxes and colouring oils etc.
(e) **Fluorescent Dyes** – A very innovative dye. Used for application in sports good etc.
(f) **Fuel Dyes** – As the name suggests it is used in fuels
(g) **Smoke Dyes** – Used in military activities.
(h) **Sublimation Dyes** – For application in textile printing.
(i) **Inkjet Dyes** – Writing industry including the inkjet printers
(j) **Leuco Dyes** – Has a wide variety of applications including electronic industries and papers.

4.3 Classification based on International Trade Commission

However the most popular classification is the one that is advocated by the US International Trade Commission. This system classifies dyes into 12 types:

- **Type 1**: Acridine dyes, derivatives of acridine
- **Type 2**: Anthraquinone dyes, derivatives of anthraquinone
- **Type 3**: Arylmethane dyes
  - **Category 1**: Diarylmethane dyes, based on diphenyl methane
  - **Category 2**: Triarylmethane dyes, derivatives of triphenyl methane
- **Type 4**: Azo dyes, based on **-**N=N**-** azo structure
- **Type 5**: Cyanine dyes, derivatives of phthalocyanine
- **Type 6**: Diazonium dyes, based on diazonium salts
- **Type 7**: Nitro dyes, based on a **-**NO_2nitro functional group
- **Type 8**: Nitroso dyes, based on a **-**N=O nitroso functional group
- **Type 9**: Phthalocyanine dyes, derivatives of phthalocyanine
- **Type 10**: Quinone-imine dyes, derivatives of quinone
  - **Category1**: Azin dyes
    - **Class (a)**: Eurhodin dyes
    - **Class (b)**: Safranin dyes, derivatives of safranin
  - **Category 2**: Indamins
  - **Category 3**: Indophenol dyes, derivatives of indophenol

    - **Category 4**: Oxazin dyes, derivatives of oxazin
    - **Category 5**: Oxazone dyes, derivatives of oxazone
    - **Category 6**: Thiazin dyes, derivatives of thiazin
- **Type 11**: Thiazole dyes, derivatives of thiazole
- **Type 12**: Xanthene dyes, derived from xanthene
    - **Category 1**: Fluorene dyes, derivatives of fluorene
        - Pyronin dyes
    - **Category 2**: Fluorone dyes, based on fluorone
        - Rhodamine dyes, derivatives of rhodamine

SELF ASSESSMENT EXERCISE 2

i. Mention four types of industrial classification of dyes and their applications
ii. Enumerate the classification of die base on used

5.0 CONCLUSION

Dyes are applied to numerous substrates for example to textiles, leather, plastic and paper in liquid form. One characteristic of dye is that the dyes must get completely or at least partially soluble in the medium which it is being put to. The rules that apply to other chemicals are similarly applicable to dyes. For example, certain kind of dyes can be toxic, carcinogenic or mutagenic and can pose as a hazard to health.

6.0 SUMMARY

In this unit,we have learnt that:

- dyes generally can be described as coloured substances that have an affinity to the substrate to which theyare being applied
- dyes may also require a mordant to improve the fastness of the dye on the material on which it is applied
- thereare different means of classification of dyes, but the most generally acceptable one is based on the International Trade Commission, which differentiated dyes into twelve categories

7.0 TUTOR-MARKED ASSIGNMENT

i. Dyes are made up of vast arrays of chemical bonding. Discuss
ii. Write short notes on dyes obtained from natural source.
iii. Mention four types of dyes and their uses.

8.0 REFERENCES/FURTHER READING

Colour Index International (3rd ed,), (1999). CD-ROM, Clarinet Systems Ltd., SDC and AATCC

Sequin-Frey, M. (1981).“The Chemistry of Plant and Animal Dyes”.*Journal of Chemical Education* **58** (4)

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UNIT 2 CLASSIFICATION OF FIBRES

CONTENTS

1.0 INTRODUCTION

Plants which yield fibres have been companion to human kind since time immemorial. Materials for rope and weaving were collected from the wild by the earliest peoples; later societies began to care for particular strands of these plants. Fibres have long been of natural origin. Human uses for fibres are diverse. They can be spun into filaments, thread, string or rope. They can be used as a component of composite materials. They can also be matted into sheets to make products such as paper or felt. Fibres are often used in the manufacture of other materials.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- Identify the sources of fibres
- Describe the several ways for classification of fibres
- Identify some of the plants and trees that give good natural fibres

3.0 HOW TO STUDY THIS UNIT

1. You are expected to read carefully, through this unit at least twice before attempting to answer the self-assessment questions or the tutor marked assignments.
2. Do not look at the solution given at the end of the unit until you are satisfied that you have done your best to get all the answers.
3. Share your difficulties with your course mates, facilitators and by consulting other relevant materials particularly the internet.
4. Note that if you follow the instructions you will feel self fulfilled that you have achieved the aim of studying this unit. This should stimulate you to do better.

4.0 MAIN CONTENT

4.1 Definition of Fibres

Fibre or **fibre** is a class of materials that are continuous filaments or are in discrete elongated pieces, similar to lengths of thread. Fibres are of great importance in the biology of both plants and animals, for holding tissues togther.

4.2 Classification of Fibres

Fibres used by man come from a wide variety of sources. They are classified into two broad types namely natural and synthetic fibres.

4.3 Natural Fibres

Natural fibres include those produced by plants, animals, and geological processes. They are biodegradable over time. They can be classified according to their origin:

(a) Vegetable Fibres: Vegetable fibres are generally based on arrangements of cellulose, often with lignin: examples include cotton, linen, hemp jute, flax, ramie, and sisal. Plant fibres serve in the manufacture of paper and cloth.

(b) Wood Fibres: Wood fibre, distinguished from vegetable fibre, is from tree sources. Forms include groundwood, thermomechanical pulp (TMP) and bleached or unbleached kraft or sulfite pulps. Kraft and sulfite, also called sulphite, refer to the type of pulping process used to remove the lignin bonding the original wood structure, thus freeing the fibres.

(c) Animal Fibres: They consist largely of particular proteins. Instances are spider silk, sinew, catgut and hair (including wool). Polar bear fibres are noted for being hollow.
(d) Mineral fibres: This comprises of asbestos. Asbestos is the only naturally occurring long mineral fibre. Short, fibre-like minerals include wollastinite, attapulgite and halloysite.

In general, natural fibres can be grouped into two categories: soft fibres and hard fibres.

4.3.1 Soft Fibres

Most soft fibres come from the bast portion of the plant. Also called the phloem, the bast lies directly under the outer bark or skin. Here the transport of the products of photosynthesis and the development of stabilizing structures take place. Through the process of retting, the bast is removed from the stems. Hemp, Flax, Jute and Ramie are soft fibres.

4.3.2 Hard Fibres

Hard fibres are comprised not only of the phloem but also partly of the hardened wood core of the plant, the Xylem. The hardness in the plant's fibres is caused by the deposit of lignin in the cell walls. Hard fibres generally come from the leaves of monocot (single seed-leaf) species, for example Sisal agave, fibre banana and diverse palms.

SELF ASSESSMENT EXERCISE

i. List carefully the different types of natural fibres you have studied.
ii. Distinguish a soft fibre from a hard one.

4.4 Human -Made Fibres

These may come from natural raw materials or from synthetic chemicals. They are of two types:

(a) Many types of fibre are manufactured from natural cellulose, including rayon, modal, and the more recently developed Lyocell. Cellulose-based fibres are of two types, regenerated or pure cellulose such as from the cupro-ammonium process and modified or derivitized cellulose such as the cellulose acetates. Fibreglass made from specific glass formulas and optical fibre, made from purified natural quartz, are also man-made fibres that come from natural raw materials. Metallic fibres can be drawn from ductile metals such as copper, gold or silver and extruded or deposited from more brittle ones such as nickel, aluminum or iron.

(b) Synthetic fibres are a subset of man-made fibres, which are based on synthetic chemicals (often from petrochemical sources) rather than arising from natural materials by a purely physical process. Such fibres are made from polyamide, nylon, polyethylene (PET) or PBT polyester, phenol-formaldehyde (PF), polyvinyl alcohol fibre (PVOH), polyvinyl chloride fibre (PVC), polyolefins (PP and PE), or acrylic polymers, although pure polyacrylonitrile (PAN) fibres are used to make carbon fibre by roasting them in a low oxygen environment. Traditional acrylic fibre is used more often as a synthetic replacement for wool. Carbon fibres and PF fibres are noted as two resin-based fibres that are not thermoplastic, most others can be melted. Aromatic nylons such as Kevlar and Nomex thermally degrade at high temperatures and do not melt. More exotic fibres have strong bonding between polymer chains (e.g. aramids), or extremely long chains (e.g. Dyneema or Spectra). Elastomers can even be used, e.g. spandex although urethane fibres are starting to replace spandex technology.

4.5 Extraction of Fibres

The extraction of bastfibres from the stems of linen, hemp, ramie, nettle and many other fibre plants is accomplished through retting. The strings of fibres in each are glued together and to the outer bark and the inner wood by pectin. During the retting process, the activity of various fungi, bacteria and weathering dissolve the pectin and the fibres can be separated by chemical and/or mechanical means.

4.5.1 Dew Retting

Dew retting takes place directly on the field. The stems of plants are harvested, gathered in bundles, stacked and left to the elements. Depending on temperature and weather, retting can take some weeks.

4.5.2 Water Retting

Water retting is done in large basins filled with water. Soaking in water, the pectin is more quickly dissolved. Earlier in Europe and still today in developing countries, plant fibres are retted in rivers and streams which often is the cause for severe water pollution.

4.6 Natural Sources of Fibres

4.6.1 Cotton

Cotton is King, the most produced and most consumed of all natural fibres. Cotton's soft, flexible qualities and its unique ability to regulate moisture and warmth make it first choice material for many industries. Few can deny the fundamental comfort of cotton in its most recognizable form, 'jeans and T-shirt', simple fashion and skin-friendly uniform of the American West. Cotton is derived from the plant *Gossypiumarboreum* L., *G. herbaceum* L. (Old World Cotton) and *Gossypiumbarbadense* L and *G. hirsutum* L (New World Cotton). New world cotton give much higher yields than those from the Old World, their fibres are finer and generally longer.

4.6.2 Flax or Linen

In Western Civilisation linen was the most important material made from plant fibres, from ancient times until the end of the 18th Century. Finds of archaic linen seeds in Iraq and in southeastern Turkey show that wild linen *Linumbienne* was cultivated as early as 9000 years ago. The living and the dead of Egypt were, for thousands of years, wrapped in linen.

Linen from the plant *Linumusitatissimum* L., grows to 120cm. Its short fibres are found in the stem. Bound together end to end and into bundles by pectin, linen fibres form strands 60 to 90cm long. Linen is extremely rip-resistant but not particularly flexible. For the finest of fibres, the green plant is harvested following its flowering period. When left until golden, middle-ripe, linen gives stronger fibres and rougher textiles. Completely ripe and dried when harvested, linen fibre is only useful for ropes and sackcloth. The extreme parallel order of flax fibres in their bundles gives linen fabric a characteristic wrinkle.

5.0 CONCLUSION

Fibres are all inclusive natural products. Synthetic fibres can be produced very cheaply and in large amounts compared to natural fibres, but natural fibres enjoy some benefits, such as comfort, over their man-made counterparts.

6.0 SUMMARY

In this unit, we have learnt that:

- fibres are of great importance in the biology of both plants and animals, for holding tissues together
- fibres are divided into tow types namely natural and synthetic or man- made
- fibres are extracted from plants by retting
- cotton and Linen or Flax are the two sources of natural fibre
- fibres are divided into two major groups- natural and synthetic.

7.0 TUTOR-MARKED ASSIGNMENT

i. Mention four types of synthetic fibres
ii. Mention the major differences between vegetable and wood fibre
iii. Discuss briefly the method of extraction of fibres

8.0 REFERENCES/FURTHER READING

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UNIT 3 NATURAL DYES AND DYEING PROCESS

CONTENTS

1.0 INTRODUCTION

Historically, natural dyes were used to colour clothing or other textiles, and by the mid-1800, chemists began producing synthetic substitutes for them. By the early part of this century only a small percentage of textile dyes were extracted from plants. Lately, there has been increasing interest in natural dyes, as the public became aware of ecological and environmental problems related to the use of synthetic dyes. The use of natural dyes cuts down significantly on the amount of toxic effluent resulting from the synthetic dye process. Natural dyes generally require a mordant, which are metallic salts of aluminum, iron, chromium, copper and others, for ensuring the reasonable fastness of the colour to sunlight and washing.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- define natural dye
- identify categories of natural dye
- produce dye from natural plant
- identify different sources of natural dye
- explain the simple dyeing procedure

3.0 HOW TO STUDY THIS UNIT

1. You are expected to read carefully, through this unit at least twice before attempting to answer the self-assessment questions or the tutor marked assignments.
2. Do not look at the solution given at the end of the unit until you are satisfied that you have done your best to get all the answers.
3. Share your difficulties with your course mates, facilitators and by consulting other relevant materials particularly the internet.
4. Note that if you follow the instructions you will feel self fulfilled that you have achieved the aim of studying this unit. This should stimulate you to do better.

4.0 MAIN CONTENT

4.1 Definition of Natural Dyes and Mordant

Natural dyes are a class of colourants extracted from vegetative matter and animal residues.

A mordant is an element which aids the chemical reaction that takes place between the dye and the fiber so that the dye is absorbed.

4.2 Types of Natural Dyes

Natural dyes can be sorted into three categories: natural dyes obtained from plants (e.g. indigo), those obtained from animals (e.g. cochineal), and those obtained from minerals (e.g. ocher).

4.2.1 Natural Dyes Obtained from Plants

(a) One example of a natural dye obtained from plants is madder, which is obtained from the roots of the madder plant. The plants are dug up, the roots washed and dried and ground into powder. During the 19th century, the most widely available fabrics were those which had been dyed with madder. Analyses of red fabrics found in King Tutankhamen's tomb show that they were dyed with madder, a plant-based dye. This red was considered brilliant and exotic. The madder plant continued to be used for dyeing until the mid-1800s when a synthetic substitute was developed.

(b) Another example of a natural dye obtained from plants is woad. Until the Middle Ages, Europeans used woad to create a blue fabric dye. The woad was a shrub that grew abundantly in parts of Europe. The colouring was in the leaves, which were dried and ground, mixed with water and made into a paste. This dye was supplanted by indigo, an ancient shrub well known to the Egyptians and Indians. Like woad, its colour lay in its leaflets and branches. The leaves were fermented, the sediment purified, and the remaining substance was pressed into cakes.

(c) Indigo prevailed as the preferred blue dye for a number of reasons. It is a substantive dye, needing no mordant, yet the colour achieved is extremely fast to washing and to light. The manufacture of natural indigo lasted well into the early 1900s. In 1905 Adolf von Bayer (the scientist who also formulated aspirin) was awarded the Nobel Prize for discovering the molecular structure of indigo, and developing a process to produce it synthetically.

4.2.2 Natural Dyes Obtained from Animals

A good example is cochineal, which is a brilliant red dye produced from insects living on cactus plants. The properties of the cochineal bug were discovered by pre-Columbian Indians who would dry the females in the sun, and then ground the dried bodies to produce a rich red powder. When mixed with water, the powder produced a deep, vibrant red colouring. Cochineal is still harvested today on the Canary Islands. In fact, most cherries today are given their bright red appearance through the artificial colour "carmine", which comes from the cochineal insect.

4.2.3 Natural Dyes Obtained from Minerals

Dyes made with minerals, coloured clays and earth oxides. For example, Ochre, made from iron ore, is one of the oldest pigments and has been in use since pre-historic times.
Categories of Natural Dyes

Table 4.1: Categories of Natural Dyes

Colours	Chemical Classifications	Common Names
Yellow and Brown	Flavone Dyes	Weld, Quercitron, Fustic, Osage, Chamomile, Tesu, Dolu, Marigold, Cutch
Yellow	Iso-quinoline Dyes	Barberry
Orange-Yellow	Chromene Dyes	Kamala
Brown and Purple-Grey	Naphthoquinone Dyes	Henna, Walnut, Alkanet, Pitti
Red	Anthraquinone Dyes	Lac, Cochineal, Madder (Majithro)
Purple and Black	Benzophyrone Dyes	Logwood
Blue	Indigoid Dyes	Indigo
Neutrals	Vegetable Tannins: gallotannins, ellagitannins and catechol tannins	Wattle, Myrobalan, Pomegranate, Sumach, Chestnut, Eucalyptus

Source: Colour Trend, U.S. Agency for International Development.

4.4 Natural Dyeing

Beautiful bright colours can be obtained by dyeing with natural dyes. Dyes can be gathered from nature or you can use dyestuff which will give you any colour under the rainbow.

4.4.1 Some Natural Dyeing Materials

a. **Alkanet Root** (*Alkaniatinctoria)*: This will give colours from bluish grey to soft burgundy. This plant grows like a weed when planted.
b. **Annato Seed** (*BixaOrellana*): Will give an orange shade, it is a good dye for cotton.
c. **Brazilwood Dust** (*Caesalpaniaechinata*): This dye will give reds. Before using the dust, it is first exposed to the air and sprinkle with water and alcohol.
d. **Cochineal** (*Dactylopiuscoccus*): The little cochineal bug will give the most colour when ground into a fine powder. Obtainable colours are dark burgundy to bright red, soft lilac and pink.
e. **Indigo Solution Natural** (Saxony blue): Produces a bright blue and is very easy to use, similar to a chemical dye. All of the dye

will be absorbed in the fiber. It is not very good to dye cotton or other vegetable fibers.

f. **Red Sandalwood** (*Pterocarpus*): This dye is beautiful for blending. It produces lovely browns and act as good shade combinations for doll hair.

g. **Madderroot** (*Rubiatinctorum*): Is available in two forms: root or dust. Colour ranges from red to red-brown and oranges. It dyes cotton well.

h. **Loqwood Concentrate** (*Hematoxyloncampechianum*): Expected colours anywhere from magenta's and brown to purples and pink. A mordant is absolutely needed. The concentrated powder will give more bluish colours. It dyes cotton well.

i. **Osage Orange Dust** (*Maclurapomifer*): Two different colours can be obtained; bright yellow and gold.

SELF ASSESSMENT EXERCISE 1

i. What is a natural dye?

ii. Describe four categories of natural dyes with respect to source and colour they produced.

4.4.2 Mordant for Natural Dyeing

Mordants are needed to set the colour when using natural dyes. Different mordants will give different results:

(a) **Alum:** ($AlK_2SO_{4;}$ Aluminum Potassium Sulfate): This is the most widely used mordant. Be careful not to use too much with wool, otherwise you will get a sticky feeling that does not come out.

(b) **Copper:** ($CuSO_4$; Copper Sulfate): This mordant is used to bring out the greens in dyes. It will also darken the dye colours, similar to using tin, but is less harsh.

(c) **Chrome:** ($K_2Cr_2O_7$; Potassium Dichromate): Chrome brightens dye colours and is more commonly used with wool and mohair than with any other fiber. Chrome should not be inhaled and gloves should be worn while working with chrome. Left over mordant water should be disposed of at a chemical waste disposal site and treated as hazardous waste.

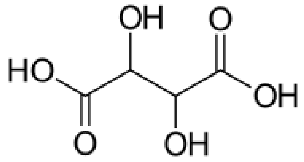
(d) **Iron:** (Fe_2SO_4; Ferrous Sulfate): Dulls and darkens dye colours. Using too much will make the fiber brittle.

(e) **Glaubersalt:** (Na_2SO_4; Sodium Sulfate): Used in natural dyes to level out the bath. Also use in chemical dye.

(f) **Spectralite**: (Thiourea Dioxide): This is a reducing agent for indigo dyeing.

(g) **Tara Powder:** (*Caesalpiniaspinosa*): Tara Powder is a natural tannin product. It is needed for darker colours on cotton, linen and hemp.

(h) **Tartaric Acid:** A must for cochineal. This mordant will expand the cochineal colours.



(i) **Tin:** ($SnCl_2$; Stannous Chloride): Tin will give extra bright colours to reds, oranges and yellows on protein fibers. Using too much will make wool and silk brittle. To avoid this you can add a pin**ch** of tin at the end of the dying time with fiber that was premordanted with alum. Tin is not commonly used with cellulose fibers.

(j) **Calcium Carbonate** ($CaCO_3$):Is to be used with indigo powder for the saxon blue colour. It can also be used to lower the acidity of a dye bath.

4.5 Making Natural Dyes from Plant Source

There is a simple experiment requires to obtain dyes from plant materials.

(a) Gathering plant material for dyeing: Blossoms should be in full bloom, berries ripe and nuts mature. Never gather more than 2/3 of a stand of anything in the wild when gathering plant stuff for dying.

(b) To make the dye solution: Chop plant material into small pieces and place in a pot. It is most appropriate to double the amount of water being added to the plant materials. Bring to a boil, and then simmer for about an hour. For a stronger shade, allow material to soak in the dye overnight.

4.6 Natural Dyeing Process

(a) **Equipment**: The water you use for dyeing should be soft. Most tap water is too hard, and you should add a softener to it. Rain water may be an ideal option. The following items are useful for dyeing; stainless steel pot, strainer, stirrer, wooden spoon, measuring utensils, like cups and spoons, kitchen scale and rubber gloves.

(b) **Wool Preparation**: When working with raw wool fleece, you must first scour the wool to remove the oil from the fiber. For 1lb of wool: fill 3-4 gallons of water in a pot with detergent. Put the wool in and slowly simmer for 45 minutes. Cool, then rinse.

(c) **Mordant Directions**: Dissolve the mordant in a small amount of hot water. Add 4-5 more gallons of water, enough to cover 1lb of wool, and heat to luke warm. Add the wool and simmer 45 minutes to 1 1/2 hours. Cool and rinse.

4.6.1 Dyeing Process

(i) Place wet wool in luke warm dye bath and slowly raise to a simmer.
(ii) Dyes from flowers, fruits, and tender leaves: simmer 30 minutes - 1 hour
(iii) Dyes from tough leaves, roots, nut hulls, and bark: simmer 1 minute - 2 hours
(iv) Cool and rinse until the rinse water is clear.
(v) Never agitate the wool or it will felt. Lift and turn it gently in plenty of water.
(vi) Never shock with extreme changes in water temperature
(vii) Do not wring or twist - squeeze gently to remove excess water. It is not necessary to cover the pot when simmer in, unless you are using chrome which is light sensitive.
(ix) Dye entire amount of wool needed for project in one bath
(x) Add white vinegar (1/4 cup per gallon) to rinse water to help soften the wool.

4.7 Fibre Dyeing

Natural dyes can dye fibres in three main forms:

(a) Direct dyes can colour fibres without other fixing agents, often after simple extraction from plant material. These include very fast colours, such as walnut and bark browns, and also dye with very poor fastness, such as Saffron (*Crocus sativus*), Safflor (*Carthamustinct*orum) and Pomegranite rinds.
(b) Adjective dyes colour fibres only in combination with a mordant. The most important mordants are metal salts (aluminum, iron, copper) and tannins. The ancient dyeing traditions of Egypt, India, China and Central America all incorporated the use of these minerals. The practices of mordant-dyeing worldwide are remarkably similar and such discoveries as the fixative properties of metal salts were made by many early peoples.
(c) Indigo dyes are a unique form of natural dye, which utilise particular processes. Complicated dye extraction using fermentation and even more complicated dyeing practices were

developed in pre-historic cultures of Europe, Asia, Africa and the Americas, wherever indigo-bearing plants have been found in nature. Indigo blues can be quite permanent when properly applied.

4.8 Dyeing Process of Leather

Dyeing Leather substrate is an uphill task. As leather has myriad of structural differences, grooves, knurls, and folds along with other sorts of imperfections. Therefore for achieving the target of a level and uniform dyeing, the dyer needs to be experienced, and have a thorough knowledge of the dyeing processes, properties and the auxiliaries that need to be used. Leather dyeing is generally done by two processes. Drum dyeing and Rub dyeing, with Drum dyeing being predominant. In the process of drum dyeing, the application of dyestuffs to the leather is done by immersing the leather in drums. The drum is then tumbled. This tumbling allows the leather to be fully penetrated by the dyes. The ultimate aim of drum dyeing is getting the desired colour, which appears level and uniform throughout the skins. The leather colourants that are used is dominated by the acid dyes which accounts for nearly 90% of the market, followed by metal complex dyes and, cationic dyes to some extent. The dyes are applied either on the grain or suede side.

4.9 Some Dyeing Patterns

(i) **Raw fibres** are generally dyed by the dipping process. They are placed in a perforated metal cylinder that is dipped into a vat full of dye.
(ii) **Velour cloth and furs** are often hand-dyed. The dye is applied with a brush that has been dipped in a dye solution.
(iii) **Batik** is an ancient method of applying coloured dyes to fabrics, usually cotton and silk. It originates in Java and now widely used throughout the world.
(iv) **Tie-dyeing**, a hand-dyeing technique often practised as a craft, can be used to create multi-coloured patterns.

SELF ASSESSMENT EXERCISE 2

i. What is a mordant? Mention two types and their features
ii. How would you dye a fabric?

5.0 CONCLUSION

The dyes were obtained from animal, vegetable or mineral origin, with no or very little processing. By far the greatest source of dyes has been from the plant kingdom, notably roots, berries, bark, leaves and wood, but only a few have ever been used on a commercial scale. These dyes can dye different shades of materials such as plastic, fibres, cotton etc.

6.0 SUMMARY

In this unit, we have learnt about:

- the types and nature of natural dyes
- sources of natural dyes
- the nature and role of mordant in dyeing process
- natural dyeing process
- simple dyeing process for fibers.

7.0 TUTOR-MARKED ASSIGNMENT

i. Describe a simple experiment for the extraction of dye from plant materials
ii. What is a mordant? Mention two types and their features
iii. In a tabular form, describe four plants and the colour of the dye they produced.

8.0 REFERENCES/FURTHER READING

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