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## LESSON 2 INTRODUCTION TO DYES

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## 2. INTRODUCTION TO DYES

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After the fabrics have been subjected to pre-treatments considered in the previous lesson, the next step is to render colour to the fabric. Dyeing is a process of colouring the fabric using dyes which are organic compounds. Dyes could be either obtained from natural or synthetic sources. This lesson deals with dyes, their classification and specific characteristics of each dye and also its selection depending on the fibre type, its end use and similar other parameters. The next lesson will consider the process of dyeing.

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### 2.0 Objectives

After going through this lesson, you will be able to

- Know about the historical background of dyes.
- Understand the basis of dye selection.
- Classify dyes on the basis of their origin.
- Learn about different Dyes and colours for textiles.

### 2.1 Introduction

Dyes are organic compounds which are widely used for imparting colour to textiles. They are produced either chemically or from plants. An interesting point about them is that unlike paint, they do not build up on the surface of the fibre but are absorbed into the pores of the material. This becomes possible because of two reasons. First, the size of the dye molecules is smaller than the size of the pores in the fibre. The dye molecules have a shape like narrow strips of paper, that is having length and breadth but relatively little thickness. This planar shape assists them to slip into the polymer system when the fibre, yarn or fabric is introduced into the dye bath.



Fig. 2.1 Dyed fabric

The second reason is the affinity of the dye to the fibre due to forces of attraction. The dye which has diffused or penetrated into the fibre is held there by the forces of attraction between the dye and the fibre. A coloured fabric is shown in Fig. 2.1.

## 2.2 Historical Background

Up to the middle of nineteenth century, the dyestuffs used for textiles were obtained from natural sources viz. vegetable, animal and mineral sources. As these dyes were not simple water-soluble substances, complex procedures were used to give rich and fast (but expensive) colours. The fabrics in Fig. 2.2 have been dyed with vegetable dyes.

In 1856 a British Chemist named William Henry Perkin, produced a brilliant mauve dyestuff (Fig. 2.3) from coal tar which was the first synthetic dyestuff. This led to an understanding of the chemistry of dyes and a number of synthetic dyes were developed with the result that by the end of the nineteenth century, the natural dyes were almost completely replaced by synthetic dyes. Interestingly there has been a flow of activity in the recent past relating to the use of natural dyes for colouring textiles.



Fig. 2.2 Picture of vegetable dyed fabric from Ajanta



Fig. 2.3 Fabric dyed in mauve colour

## 2.3 Selection of Dyes

To select the proper dye for a fibre, it is necessary to know which dyes have an affinity for the vegetable (Fig. 2.4), animal (Fig. 2.5), or man made fibres (Fig. 2.6). In general, the dyes used for cotton and linen may be used for viscose rayon, but other fibres having different chemical structures require different dyes.

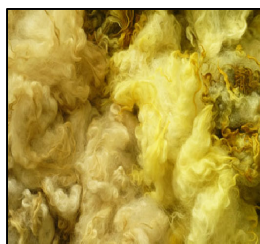


Fig. 2.4 Vegetable fibres



Fig. 2.5 Animal fibres



Fig. 2.6 Man made fibres

Direct dyes (Fig. 2.7) are the easiest to produce, the simplest to apply, and the cheapest in their initial cost as well as in application. They, however, like other dyes have their own limitations. One of these is the degree of colour fastness.



Fig. 2.7 Direct dyes



**Fig. 2.8 Different dyes of different colours**

Fastness of colour refers to its ability to remain unchanged. Different dyes of different colours (Fig. 2.8) have different degrees of fastness to various conditions. For example a colour that may have good fastness to washing may have poor fastness to light. Also certain dyes may bleed, or run, when wet and may cause discolouration of other fabrics. Some dyes may crack, or rub off, due to frictional wear.

Once a colour has been selected, it is essential that its formulation should be kept consistent. Each batch that is dyed must have its lot number. Since variation can occur in such factors as chemical concentration, fibre structure, and water content or temperature, any of these can cause a slight change in colour thus rendering each dye lot to be slightly different.

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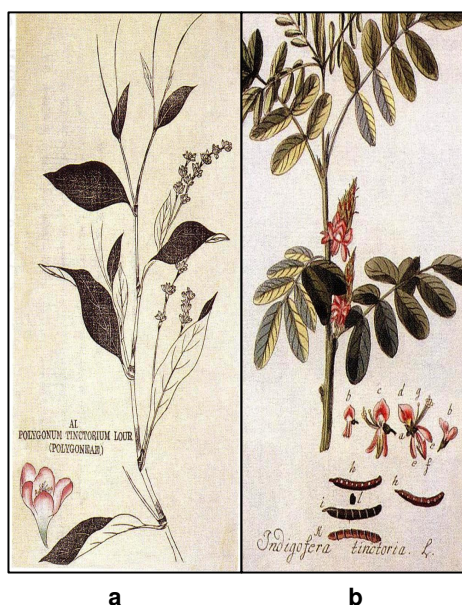
## Self-check Questions

1. Who invented the first synthetic dye and when?
  2. What do you mean by colour fastness?
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## 2.4 Classification of Dyes

Dyes, as stated earlier, can be obtained from natural sources such as vegetable matter, mineral or insects or are manufactured in the factory from petrochemical feedstock. It may, however, be recalled that the first synthetic dye (Mauveine) by Perkin was made from Coal tar.

Amongst natural dyes, indigo is well known for its brilliant blue colour and was obtained by fermenting the leaves of a plant (Fig. 2.9). The red coloured lac dye is extracted from lac, a resinous protective secretion of a tiny insect.



**Fig. 2.9 Plants from which dyes are extracted: a. Al Polygona Tinctoria Lour b. Indigofera Tinctoria**

The production of natural dyes and their use are both complex. So it is no wonder that they have been gradually superseded by synthetic dyes. For example, indigo was synthesized in 1880 and the king of natural dyes gradually went into oblivion. With environmental concerns that earmark the present age, there are some signs of the revival of natural dyes.

Amongst the dyes that originate from minerals, iron oxide powder gives a brown colour and buff derived from ferrous sulphate has also been used for colouring fibres. The dyes that will be described in this lesson can also be used for printing of fabrics. The pigment colours, which are used for printing, have no affinity for fibres and therefore do not come strictly under the definition of dyes. They are therefore not included here.

## 2.5 Dyes and Colours for Textiles

Various dyes for textile materials may be represented in chart format (Chart 2.1) as follows:

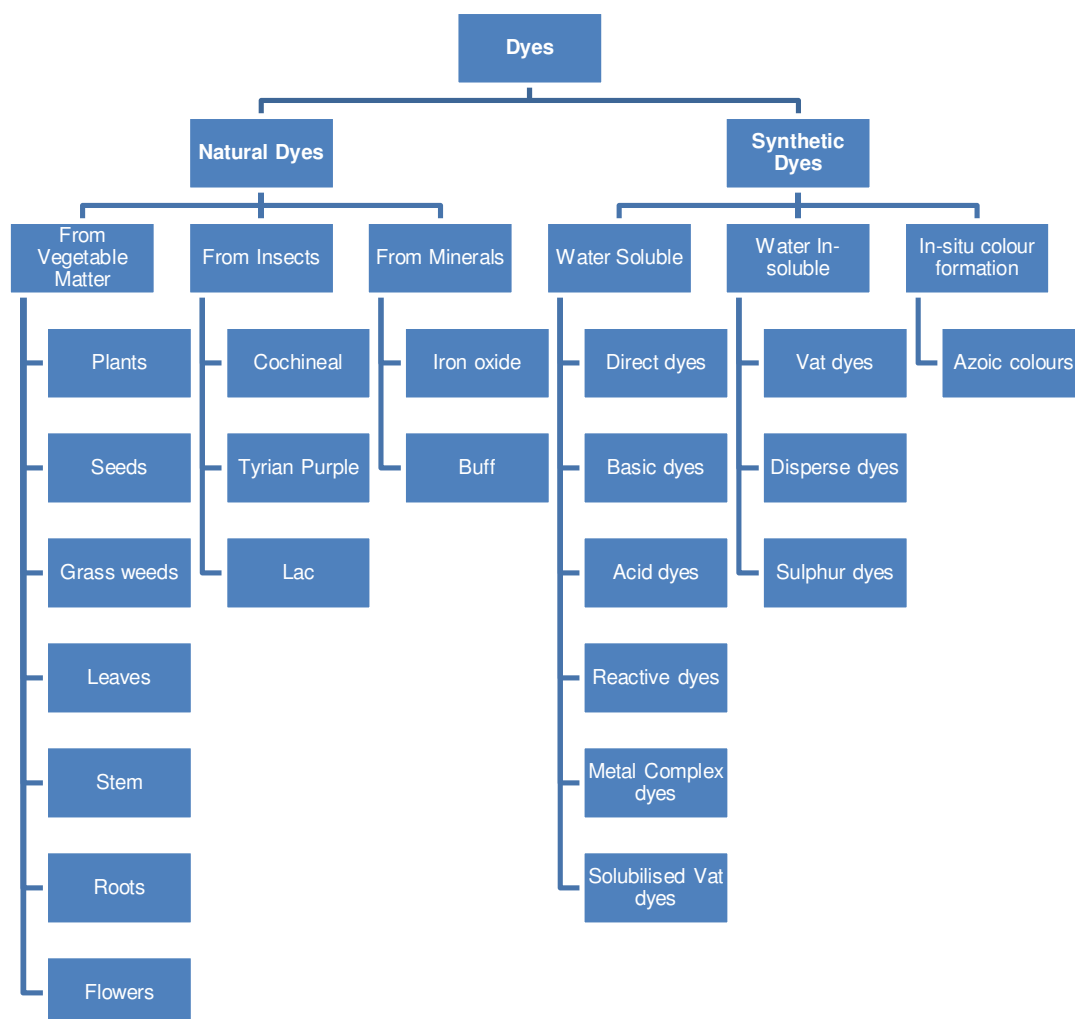


Chart 2.1 Dyes for Textiles

Presently (1999) the natural dye consumption is equivalent to only 1% of the world synthetic dye consumption. In this lesson we will therefore limit our discussion to synthetic dyes only.

## Activity

1. Get some samples of:

- Fabrics dyed with natural dyes.
- Fabrics dyed with synthetic dyes.

Wash these fabrics manually and check their colour fastness and make a comparative chart.

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## 2.6 Synthetic Dyes

The synthetic dyes listed in Chart 2.1 will now be briefly described:

### 2.6.1 Direct Dyes (Fig. 2.10)

- Direct dyes are cheap and easy to apply, but of poor fastness quality.
- These dyes are also known as 'salt dyes' or cotton colours, which dye cotton, other vegetable fibres and viscose rayon.
- They are readily soluble in water. Colours of cotton fabrics dyed with direct dyes are not fast.
- They are applied to Cellulose fibres from aqueous liquor in which an electrolyte is added, which is usually Sodium Chloride as it accelerates the rate at which the dye is picked up by the fibre.
- They generally bleed. To make them fast on fabric add Sodium Bicarbonate for warm colours, and Copper Sulphate for cool colours.



Fig. 2.10 Direct dyes

### 2.6.2 Acid dyes (Fig. 2.11)



Fig. 2.11 Acid dyes

- These are soluble in water and are applied under acidic conditions.
- The acid dyestuff is mostly used for wool and silk and to a less extent nylon and acrylic fibres.
- The maximum quantity of dye absorbed depends on the amount of  $\text{H}_2\text{SO}_4$  present in the bath.
- Acid dyes are inexpensive dyes.
- They are fast to light, but they are not fast to washing.

### 2.6.3 Vat dyes (Fig. 2.12)

- They are insoluble in water, but they are made soluble by the use of a strong reducing agent, such as Sodium hydrosulphite dissolved in sodium hydroxide.
- These are the fastest dyes for cotton, linen and rayon.
- They also may be applied to wool, nylon, polyester etc.
- Vat dyes are hot water dyes.
- Hot water dyes are available in both powder and liquid form.
- The first synthetic Vat dye was an *Indigo* created in 1879.
- Vat dyes are expensive because of the initial cost as well as the method of application.



Fig. 2.12 Vat dyes

### 2.6.4 Azoic colours (Fig. 2.13)

- The Azoic colours are applied to cotton in two stages. The first consists of treatment with naphthol and the second by treatment of the naphtholated material with diazotized base or diazotized salt. The colour development takes place in-situ by the coupling reaction between naphthol and diazo component.
- They are quite fast to washing and have poor to *excellent* light fastness.
- Azoic colours are used mostly on cotton and for special purposes on nylon
- Azoic colours are sometimes referred to as ice dyes because ice is frequently used to bring the dyes to low temperatures.
- Azoic colours give bright, high intensity colours, much more so than the common dye classes.



Fig. 2.13 Azoic colours

- These are cold water dyes and are most suitable for cold dyeing techniques such as Batik, Tie-Dye, etc.

### 2.6.5 Basic dyes (Fig. 2.14)

- The first coal tar dye was a basic dye.
- It is applied to wool, silk, cotton, acrylic, and modacrylic fibres.
- When acrylic fibres were first marketed, they were very difficult to dye due to lack of specific dye sites in the fibres. Such groups were introduced into the fibre and brilliant colours can now be obtained with these dyes.
- They give good fastness and bright shades to acrylics.



Fig. 2.14 Basic dyes

### 2.6.6 Reactive dyes (Fig. 2.15)

- They were first developed in 1956 by I.C.I., U.K.
- The dye is retained by means of a chemical reaction between the dye and the fibre. As such their fastness properties are excellent.
- The fibres most readily coloured with reactive dyes are natural and man made cellulosic fibres, natural protein fibres and polyamide fibres.
- With some reactive dyes, the dyeing can be carried out at room temperature. However with most reactive dyes, the dyeing is carried out at high temperatures (upto the boil).



Fig.2.15 Reactive dyes

### 2.6.7 Disperse dyes

- The fibres that are most commonly dyed with disperse dyes are cellulose diacetate, cellulose triacetate and polyester fibres (Fig. 2.16). To a lesser extent acrylic and nylon fibres are also dyed with disperse dyes.
- Polyester fibres being hydrophobic and with significant crystalline content, the assistance of high temperature, high pressure and carriers (which swell the fibre) is taken to achieve satisfactory dyeing.



Fig. 2.16 Disperse dyed fabric

### 2.6.8 Sulphur dyes (Fig. 2.17)

- Natural and man made cellulosic fibres are readily dyed with Sulphur dyes.
- Water soluble or leuco form of the dye is produced through reduction of the dye with Sodium Sulphide or Sodium Hydrosulphite.
- The dye liquor is heated to obtain satisfactory rate of dyeing
- Once the dye is within the fibre, the reduced Sulphur dye is converted to its original insoluble form by oxidation with an oxidizing agent like Sodium perborate



Fig. 2.17 Sulphur dyes

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### Self-check Questions

3. Name dyes with the following characteristics:
  - i) Cheap and easy to apply but not fast.
  - ii) Soluble in water and applied under acidic conditions.
  - iii) To which class does the synthetic indigo dye belong?
  - iv) Which is the most suitable dye for polyester?

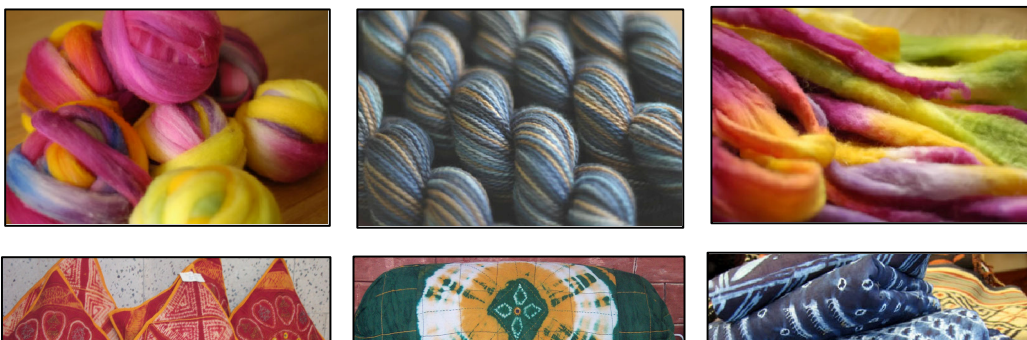
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### Activity

2. Classify dyes on the basis of their origin.
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## 2.7 Value Addition

Selection of the proper dye-fibre system is essential for achieving good results (Fig. 2.18). The colour of the fabric and its quality are very important considerations, when buying any fabric. Choice of the right dye can lead to beautiful colours and this adds value to the fabric.



## **2.8 Assignments**

### **2.8.1 Class assignments**

- i) Choose one colour (say Red) and prepare a shade card showing tints and shades from collected fabric samples.

### **2.8.2 Home assignments**

- i) Which are the important synthetic dyes? Give one unique characteristics of the listed dyes.

## **2.9 Summing Up**

In this lesson, we have learnt about the various types of dyes like direct dyes, Vat dyes, Acid dyes, Basic dyes, Reactive dyes, Sulphur dyes, disperse dyes and azoic colours. The suitability of these dyes for different fibres and their limitation in terms of light and wash fastness has also been discussed here.

## **2.10 Possible Answers to Self-check questions**

1. William Henry perkin in 1856.
2. Fastness of colour refers to its ability to be retained by the fabric and to remain unchanged. Different dyes of different colours have different degrees of fastness to various conditions. For example a colour that may have good fastness to washing may have poor fastness to light.
3. i) Direct dyes, ii) Acid dyes, iii) Vat dyes, iv) Disperse dyes.

## **2.11 Terminal questions**

1. What are the main characteristics of vat dyes?
2. Give a brief account of the historical background of dyes.
3. What are the main considerations in selecting a dye for a specific fibre system?
4. Write short notes on direct dyes and azoic dyes.

## 2.12 References and Suggested Further Reading

1. Choudhary, A. K. R. 2006. Textile Preparation and Dyeing. Science Publishers, New Delhi.
2. Gohl, E. P. and Vilensky, L. D. 2005. Textile Science. CBS Publishers & Distributors, New Delhi.
3. Grosicki Z. 1988. Watson's Textile Design & Colour. Universal Publishing Corp., Bombay
4. Sadov, F. et al. 1978. Chemical Technology of Fibrous Materials. Mir Publishers, Moscow.

## 2.13 Glossary

1. Absorbed Got sucked or consumed
2. Bleed To get diffused; spreading of dyes and colors
3. Brilliant Having striking color
4. Cheapest Of quite a low cost
5. Concentration Increase in density
6. Consistent The same throughout in structure or composition
7. Construction Building something
8. Crack To get separated or break
9. Crock Release color when rubbed, of badly dyed fabric
10. Cured Treated through a chemical or physical process to improve its properties
11. Discolour Spoil the colour, Stain
12. Enhancing Increase
13. Excellent Bright attractive colour
14. Expensive Costly
15. Fastness The quality of the colour being fixed on fabric

16. Finishing A decorative texture or appearance of a surface
17. Friction Rubbing
18. Hydro sulphide A chemical ( $H_2S$ )
19. Initial The very first
20. Intricate Complex
21. Limitation Restriction
22. Mauve A moderate purple
23. Mineral Solid homogeneous inorganic substances occurring in nature having a definite chemical composition
24. Mordant It is the chemical agent that binds the dye to a fibre.
25. Pores Small holes
26. Reducing Lessening
27. Resins Any of a class of solid or semisolid viscous substances
28. Rub off To remove by rubbing
29. Saturation The process of permeating or infusing
30. Serviceability ability to be used
31. Slight Very little
32. Sodium Hydroxide Caustic soda
33. Structure The shape