CHEMISTRY

THEORY PAPER: APPLIED COMPONENT (DRUGS AND DYES)

(as per Model CBSGS curriculum)

B.Sc. (Prog.) Semester V

Introduction to the dye-stuff Industry

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Teacher's e-Kit: Text material

TITLE:	Introduction to the dye-stuff Industry
Key words for Search:	Natural and Synthetic dyes.

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Suggested Readings:

- Chemistry of Synthetic Dyes, Vol I – VIII, Venkatraman K., Academic Press 1972
- The Chemistry of Synthetic Dyes and Pigments, Lubs H.A., Robert E Krieger Publishing Company, NY ,1995
- Chemistry of Dyes and Principles of Dyeing, Shenai V.A., Sevak Publications, 1973
- https://colour-index.com/assets/files/upl/Introduction-to-the-Colour-Index-April-2013.pdf
- https://www.tandfonline.com/doi/abs/10.1080/19447015708688148?journalCode=jtip20
- https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1478-4408.1982.tb03625.x

Web-links:

https://www.fibre2fashion.com/industry-article/5346/colour-index-for-dyes

https://www.researchgate.net/publication/340027864_A_Review_On_Classifications_Recent_Synthesis_And_Applications_Of_Textile_Dyes

Activities:

- Tell your students to find natural and synthetic dyes.

Table of Contents

Emphasis on Name of the Scientist, dyes and the year of the discovery is required. (structure is not expected)..... 12

SYLLABI OF THIS MODULE:

3.0 Introduction to the dye-stuff Industry

- **3.1.2 Introduction to the dye-stuff Industry**
- 3.1.2 Natural and Synthetic Dyes Natural Dyes: Definition and limitations of natural dyes. Examples and uses of natural dyes w.r.t Heena, Turmeric, Saffron, Indigo, Madder, Chlorophyll –names of the chief dyeing material/s in each natural dye [structures not expected], Synthetic dyes: Definition of synthetic dyes, primaries and intermediates. Important milestones in the development of synthetic dyes – Emphasis on Name of the Scientist, dyes and the year of the discovery is required. (structure is not expected)

Learning outcomes:

Upon completion of this course, student will be able to

1. *Explain the concept of* Natural and Synthetic *of dyes.*
2. *Explain the* uses of natural dyes.
3. *Describe the* milestones in the development of synthetic dyes.

- **Dyes are colored organic compounds that are used to impart color to various substrates, including paper, leather, fur, hair, drugs, cosmetics, waxes, greases, plastics and textile materials.**

- **A Dye is a colored compound, normally used in solution, which is capable of being fixed to a fabric.**

Optical brighteners or whiteners which may be called white dyes are included in term dye.

Classification

- **There are several ways for classification of dyes.**
- **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 are:**
- **Classification based on the source of materials**
- **classification of the Dyes- Based on the nature of their respective chromophores.**
- **Classification by methods of application.**
- **Classification based on the source of materials**
- **A very common classification of the dyestuff is based on the source from which it is made. Accordingly the classification could be:**
- **Natural Dyes**
- **Synthetic Dyes**
- **Natural Dye**
- **Natural dyes are dyes or colorants derived from plants, invertebrates, or minerals.**
- **The majority of natural dyes are vegetable dyes from plant sources. E.g. roots, berries, bark, leaves, and wood.**
- **Other organic sources include fungi and lichens.**

Synthetic Dyes

- **Almost all the colors that you see today are Synthetic dyes. Synthetic dyes are used everywhere in everything from clothes to paper, from food to wood. This is**

because they are cheaper to produce, brighter, more color-fast, and easy to apply to fabric.

- **E.g. Acid Dyes, Azo Dyes, Basic Dyes, Mordant Dyes, etc**
- **Turmeric (*Curcurma longa*, Zingiberaceae)**
- **is used mostly today to color foods (such as pickles),**
- **but has been used to dye clothing.**
- **Turmeric is historically one of the most famous and brightest of all the naturally occurring yellow dyes. It is extracted from the fresh or dried rhizones of the turmeric plants which are native to India. It is the only yellow substantive dye. It can be used to dye silk, wool and cotton. It is sensitive to light, soap and alkali.**
- **Saffron or kesar**
- **(crocus sativus)**
- **saffron is a yellow orange dye of polyene class extracted from dried stigmas of crocus sativus.**
- **Main color substance of saffron is crocine(conjugated polyene chain of crocetin and gentiobiose residue).**
- **It is water soluble caretonoids, used in food and medicine as colouring matter.**
- **Saffron is used for its colour, taste and aroma.**
- **CHLOROPHYLL**
- **It is green plant pigment.**
- **It acts as catalyst in the process of photosynthesis**
- **This biochemical pigment is member of**
- **porphyrin family.**
- **TYRIAN PURPLE OR ROYAL PURPLE**
- **it was extracted from a gland of purple snail by a process**
- **developed by phoenicians.**

- **it was costly**
- **chemically it is 6, 6*-dibromo indigio**
- **Henna (*Lawsonia inermis*, Lythraceae)**
- **By 3000 B.C., Greek women used henna (Lawsonia inermis, Lythraceae) to dye their hair.**
- **The leaves are ground into a paste that has a great affinity for protein.**
- **Henna is still used in hair preparations.**
- **Dyeing the skin with henna is practiced in many Near Eastern countries.**
- **Dyeing the skin with henna is practiced in many Near Eastern countries.**
- **Indigo (*Indigofera tinctoria*, Fabaceae)**
- **Indigo (Indigofera tinctoria, Fabaceae) has been one of the most important dyestuffs; this dye was used as far back as 6000 years in China.**
- **Indigo produces an intense deep blue color. The leaves and branches of the plant are harvested, placed in a vat, covered with water, and permitted to ferment.**
- **The sludge of partially rotted plant material which settles to the bottom is collected and pressed into cakes.**
- **When dry, these cakes produce a powder that makes a colorless solution.**
- **The color only develops when an item is dipped into the solution, removed and then exposed to air.**
- **Indigo dyeing and the cultivation of the plant originated in India. Because of the good quality of the dye, indigo became an important item of trade between India and other parts of the world by 300 B.C.**
- **Dyers in Europe tried to resist the importation of indigo into Europe and were able to do so for a long time. Finally, however, quality won out.**
- **Indigo was an early crop in colonial South Carolina. South Carolina indigo was considered excellent, but as the economics were not too good, it was replaced by rice.**

- **The leaves contain about 3% indigo.**
- **Synthetic indigo was produced in 1897.**

Logwood (*Haematoxylon campechianum*, Fabaceae)

- **Logwood (*Haematoxylon campechianum*, Fabaceae) came from the New World.**
- **The wood of this tree permitted dyeing things black for the first time.**
- **Although not used today for dyeing, haematoxylon stain is used as a histological stain in blood analysis.**
- **Madder**
- **Common Name:**
- **Madder, Manjistha, Majith**
  Botanical Name:
- **Rubia cardifolia (Indian Madder) Rubia tinctoria (European Madder)**
  Our Trade Name:
- **RUBIA**
  Natural Dye:
- **Red, Pink and Orange dyestuff for Textiles.**
- **Madder is one of the oldest Natural Dyes. In a way Indigo and Madder are the main ancient Natural Dyes used by man for dyeing textile for ages.**

  The cultivation of Madder needs sub topical climates and prefers moist soil. It is cultivated in the foots of Himalayas in huge quantity.

- **ALIZARIN:**
  Madder (*Rubia tinctoria*, Rubiaceae)
- **This dye was introduced into Europe in the late Middle Ages.**
- **The color of the British soldier's uniform in the Revolutionary War was produced by madder.**
- **sometimes called Turkey red.**
- **The dyestuff is found in the root of the plant. (ruberythric acid)**

- **Changing the mordant can give red, pink, lilac, orange, black, and brown colored pigments.**
- **Alizarin (a compound derived from madder) is usually used with an aluminum mordant.(Also used as a biological stain.)**
- **Madder (*Rubia tinctoria*, Rubiaceae)**
- **Madder (*Rubia tinctoria*, Rubiaceae) has been used since ancient times.**
- **One form of this dye is sometimes called Turkey red.**
- **The dyestuff is found in the root of the plant.**
- **The compound in the plant is ruberythric acid.**
- **Alizarin (a compound derived from madder) is usually used with an aluminum mordant.**
- **Cochineal**
- **In 1518, the Spaniards discovered the indigenous people of Mexico using cochineal "seeds" as a dye. They later found that the dye did not derive from seeds but the cochineal bug. The dye was used throughout Mexico and Guatemala where the bug thrived on the nopal or opunti cactus. As the insect matured the wingless dye-yielding females were swept off the leaves to which they were attached and plunged into hot water. The dead insects were then laid in the sun or placed in a bag and put in the oven to dry. After the insects were dried they were ground into a fine powder. It takes 70,000 dried insects to produce a pound of dye. An acre of nopal cactus yields approximately 250 to 300 pounds of insects. Cochineal is more costly than madder and is easily adulterated. Dark burgundy to bright red to soft lilac and pink can be obtained from cochineal. Both wool and silk are successfully dyed with cochineal when tin or alum is used as the mordant.**
- **What is Cochineal?**
- **Cochineal insects or plant seeds – plant or animal?**
- **Cochineal dye was introduced into Europe in the late 1500s by Spanish explorers from South and Central America. No information was provided on the source or**

nature of cochineal because the Spaniards closely protected their supply. More on the history and origins of cochineal in Latin America here

Dried cochineal looks like small silver-grey peppercorns or plant seeds.

Before microscopes where in use, European scientists argued for a long time as to whether cochineal was a plant, an animal or a mineral. We now know that cochineal is a female scale insect that lives on prickly pear cactus plants (*Opuntia* or nopal) native to Central and South America.

Scale insects are plant-sucking bugs that are covered by a white fluffy, protective coating and cochineal bugs produce carminic acid as a by-product to deter predators. Crimson, fuchsia, raspberry and scarlet reds can be obtained from cochineal. The red colorant is used in drinks (e.g. Campari) and in foods (under the code E120), and in drugs and cosmetics.

Polish cochineal, Kermes, Lac and St John's Blood are produced from different scale insects that are more or less closely related to true cochineal insects.

The term cochineal may be applied either to the living or dried cochineal insects or to cochineal dye which is obtained from them. It takes about 155,000 cochineal insects to produce 1 kilo of cochineal dye.

- **The insect produces carminic acid that deters predation by other insects.**
- **Carminic acid, which occurs as 17-24% of the weight of the dry insects, can be extracted from the insect's body and eggs and mixed with aluminum or calcium salts to make carmine dye (also known as cochineal).**
- **Carmine is today primarily used as a**
- **food colouring and for cosmetics.**
- **LIMITATION OF NATURAL DYES**
- **1. It is time consuming to extract from the raw materials.**
- **2. Availability of the natural dyes are limited.**

- **3. As the natural dyes are extracted from plants mostly, they are dependent on the growing seasons, which is unlike the synthetic dyes that are produced in the laboratories.**
- **4. Even though natural dyes produce bright colors and variety of shades but tend to fade faster than the synthetic dyes.**
- **5. Consistency is an issue as no two dye lots are identical due to the impurities in them.**
- **6. Some mordant used along with natural dyes may to toxic to an extend. Alum is safer to use though entirely not nontoxic.**
- **7. Some fibers such as silk and wool can be dyed by simply dipping them in the dye but cotton requires a mordant.**
- **8. Synthetic fibers, which are becoming widely popular can not be dyed with natural dyes**
- **Important milestone in the development of synthetic dyes**
- **The first human-made organic dye, mauveine, was discovered serendipitously by William Henry Perkin in 1856, the result of a failed attempt at the total synthesis of quinine.**
- **In 1858, Griess discovered diazotisation and coupling on in the fibre**
- **In 1863, Martius developed Bismarkbrown. It was first soluble azo dye**
- **In 1861, aniline yellow was developed for light food by C. Mene**
- **1878, Baeyer synthesised indigo**
- **In 1884, Bottiger prepared congo red , first of the direct common dyes**
- **In 1901, Rene Bohn prepared Indanthrene, first anthraquinonoid vat dye**
- **In 1920, R. Clavel introduced disperse dyes which is solved the problem of dyeing hydrophobic fibres.**
- **In 1929 Krais showed that fluorcent brightening of textiles can be achieved by aesculin(6,7-dihydroxy coumarin)**

- **In 1934 ICI introduced the use of aminostilbene disulphonic acid as brightening agent**
- **In 1956 ICI introduced a new class of dyes called an reactive dyes.**
- **e.g. Procian dyes and Remozal dyes. They are fiber reactive dyes that is often used in silk painting**