Lecture 2

Dyestuff Industry
LECTURE 2
DYESTUFF INDUSTRY

The dyestuff industry plays an important role in the overall growth of the chemical industry. The preparation and usage of dyestuff is one of the oldest forms of human activities. The usage of natural dyestuff dates back to the bronze age. Dye flax fibres have been found in the Republic of Georgia dated back in a prehistoric cave 36,000 BP [Balter and Make, 2009; Kavavadze et al., 2009]. Archeological evidence shows that particularly in India and Phoenicia, has been extensively carried out for over 5000 years. The dyes were obtained from animal, vegetable or mineral origin with no or little processing. First synthetic organic dye, mauveine, was discovered by William Henry Perkin in 1856 [Wikipedia].

There is also mention of dye in the Bible and other works of classical antiquity. It was in 2600 BC when earliest written records of the use of dyestuffs were found in China. Synthetic dyestuffs now available in several hues are amongst the oldest chemicals produced by man [Lalbhai, 2007]. Textile, carpet, and garment industry is one of the largest and most prominent sectors as a major portion of the dyes are used in the textile industry, growth of the textile industry has a direct impact on the growth of the dye stuff industry.

Textile dyestuff had a worldwide market of around US $ 5.7 billion. Largest categories are reactive and disperse dyes that accounts for about 44% of total value. Asia pacific represents largest share and accounts for about 40% global share. At a production of 130,000 MT per annum, Indian dye stuff industry contribute to just 7% of the world’s global production. Installed and production capacity of dyes and dyestuffs are given in Table M-IX 2.1.

Dyes are the coloured, ionizing and aromatic organic compounds which has affinity to the substrate to which it is being applied. The dye is generally applied in an aqueous solution which may also require a mordant for improving the fastness of the material on which it is applied. Classification of dyes is given in Table M-IX 2.2.

Colors are an integral part of human perception and life. Much before the invention of synthetic dyestuffs, natural and vegetable colors were in use in India for centuries. Chromphone in Important Class of Dyes is given Table M-IX 2.3 [Austin, 1984]. Perkins development of the first synthetic dye in 1856 led to the birth of European dyestuffs industry and use of synthetics dyes widely extended to all textiles substrates. The well-development textile industry in India soon
started use of synthetic dyes and depended on imported organic dyestuffs till forties. The start up of Arlabs Ltd., in 1940, followed by other dyestuffs companies in fifties and sixties led to the establishment of the indigenous industry. In the development phase that followed subsequently, India slowly emerged as the supplier of dyestuffs.

**DEMAND AND SUPPLY**

The overall production capacity of dyestuffs is 200,000 tonnes per annum. With the ever increasing standards of quality and reliability, Indian dyestuffs industry meets more than 95% of the domestic requirement, out of which textile industry consumes nearly 60% and the remaining is shared by paper, leather & other consumer industries. As far as pigments are concerned, the market size is 115,000 tonnes. Production of pigments and major dyes is shown in Figure M-IX 2.1. The main consumer industries are printing inks, paints, plastics, rubber, etc., accounting for 70% of the end use. Table M-IX 2.5 shows various dyes intermediate and their structure, methods of preparation and their uses.

**Pigments Production, India (‘000 tonnes) Production of Major Dyes (‘000 tonnes)**

![Graph showing Pigments Production](image1)

**Figure M-IX 2.1: Production of Pigments and Major Dyes**

Source: CAMI

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Table M-IX 2.1: Installed and Production of Dyes and Dyestuffs (000’ MT)

<table>
<thead>
<tr>
<th>Major Groups/Products</th>
<th>Installed Capacity (2009-10)</th>
<th>Production (2010-11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DYES AND DYESTUFFS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Azo Dyes</td>
<td>8.70</td>
<td>2.80</td>
</tr>
<tr>
<td>Disperse Dyes</td>
<td>6.50</td>
<td>0.53</td>
</tr>
<tr>
<td>Fast Colour Bases</td>
<td>0.60</td>
<td>0.09</td>
</tr>
<tr>
<td>Ingrain Dyes</td>
<td>0.50</td>
<td>0.70</td>
</tr>
<tr>
<td>Optical Whitening Agents</td>
<td>3.40</td>
<td>3.04</td>
</tr>
<tr>
<td>Organic Pigment Colours</td>
<td>11.00</td>
<td>21.83</td>
</tr>
<tr>
<td>Pigment Emulsions</td>
<td>6.30</td>
<td>5.63</td>
</tr>
<tr>
<td>Reactive Dyes</td>
<td>7.90</td>
<td>2.40</td>
</tr>
<tr>
<td>Sulphur Dyes (Sulphur Black)</td>
<td>3.30</td>
<td>8.60</td>
</tr>
<tr>
<td>Vat Dyes</td>
<td>3.00</td>
<td>1.60</td>
</tr>
<tr>
<td>Solubilised Vat Dyes</td>
<td>0.10</td>
<td>0.04</td>
</tr>
<tr>
<td>Naphthols</td>
<td>3.60</td>
<td>0.07</td>
</tr>
<tr>
<td>TOTAL</td>
<td><strong>54.90</strong></td>
<td><strong>47.33</strong></td>
</tr>
</tbody>
</table>

Sources: Annual Report 2011-2012, Department of Chemical and Fertilizers, Govt. of India

CLASSIFICATION OF DYES:

Dyes can be classified in various ways based on origin, dyeing process, chromophores and application. Classification of dyes based on application has been commonly used [Table M-IX 2.4].
### Table M-IX 2.2: Classification of Dyes

<table>
<thead>
<tr>
<th>Based on origin of dyes</th>
<th>Natural or synthetic dyes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Organic or Inorganic</td>
</tr>
<tr>
<td><strong>Based on the dyeing Process</strong></td>
<td>Acid dyes, Basic dyes, direct or substantive dyeing, vat dyes, reactive dyes, disperse dyes, azo-dye, sulphur dyes, fluorescent brightening agent</td>
</tr>
<tr>
<td><strong>Based on chromophore</strong></td>
<td>Acridined yes, Anthraquinone dyes, Aryl metahne dyes, Azo dyes Cyanine dyes, Diazonium, dyes, Nitroso dyes, Phthalocyanine dyes, Quinoneimine dyes( azine dyes, Indamins, Indophenols, oxazone, Thiazin).Thiazole dyes, Xanthate dyes</td>
</tr>
<tr>
<td><strong>Based on application</strong></td>
<td>Food, cosmetics and drug dyes, Laser dyes, Leather dyes, Solvent dyes, Contrast dye, Carbine dyes</td>
</tr>
<tr>
<td><strong>Based on Colour index</strong></td>
<td>Colour index recognizes 26 types of dyes by chemical classification</td>
</tr>
</tbody>
</table>

Source: Austin, 1985; CPCB, 2004

### Table M-IX 2.3: Chromphone in Important Class of Dyes

<table>
<thead>
<tr>
<th>Dye</th>
<th>Chromophore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azo dyes</td>
<td>-N+N-</td>
</tr>
<tr>
<td>Nitro</td>
<td>-NO₂</td>
</tr>
<tr>
<td>Nitroso</td>
<td>-NO(or =N-OH)</td>
</tr>
<tr>
<td>Ethylene</td>
<td>&gt;C=C&lt;</td>
</tr>
<tr>
<td>Carbonyl group</td>
<td>&gt;C=O</td>
</tr>
<tr>
<td>Carbon nitrogen group</td>
<td>&gt;C=NH</td>
</tr>
<tr>
<td></td>
<td>–CH≡N-</td>
</tr>
<tr>
<td>Carbon sulphur groups</td>
<td>&gt;C=S</td>
</tr>
<tr>
<td></td>
<td>&gt;C–S–S–C&lt;</td>
</tr>
</tbody>
</table>
### Table M-IX 2.4 Process Application Based Dyes

<table>
<thead>
<tr>
<th>Dyes Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acid dyes</strong></td>
<td>Acid dyes are water soluble anionic dyes and insoluble in acid bath. Acid dyes are used for dying of wool, silk, nylon, acrylic fibre, paper, leather.</td>
</tr>
<tr>
<td><strong>Basic dyes</strong></td>
<td>Basic dyes are water soluble cationic dyes. Basic dyes are mostly amino and substituted amino compounds. Basic dyes are used for dyeing, acrylic fibre, cotton, wool, paper.</td>
</tr>
<tr>
<td><strong>Direct dyes</strong></td>
<td>Direct dyes are used in a neutral or slightly alkaline dye bath without addition of mordant. Direct dyes are used for dyeing cotton, wool, silk, paper, nylon. They are generally azo dyes.</td>
</tr>
<tr>
<td><strong>Disperse dyes</strong></td>
<td>Disperse dyes are used for dyeing for dyeing synthetic fibre like cellulose acetate, polyesters, nylon and acrylic fibres. These dyes are applied as finely divided materials in presence of dispersing agent.</td>
</tr>
<tr>
<td><strong>Vat dyes</strong></td>
<td>Vat dyes have highly complex structures and are insoluble in water and are used after reduction in alkaline liquor which produces water soluble alkali salt.</td>
</tr>
<tr>
<td><strong>Reactive dyes</strong></td>
<td>Reactive dyes react to form covalent bond which directly react with the fibre and provide excellent wash resistance. Eg. Procin MX, Cibacron F and Drimarene K</td>
</tr>
<tr>
<td><strong>Mordant dyes</strong></td>
<td>Some dye combine with metallic salt (mordant) which improve the fastness of dye. Eg Chrome dyes. Potassium dichromate is used as mordant.</td>
</tr>
<tr>
<td><strong>Azoic dyeing</strong></td>
<td>In azoic dyeing, colours are made on the fibre by coupling diazotized materials while on contact with fibre. Final colour is controlled by the choice of diazoic and coupling components.</td>
</tr>
<tr>
<td><strong>Sulphur dyes</strong></td>
<td>Sulphur Black dye is most commonly used sulphur dyes. Colour is produced by reacting sulphide and polysulphides with chlorinated aromatics. It is used for cotton cloth.</td>
</tr>
<tr>
<td><strong>Food dyes</strong></td>
<td>Food dyes can be direct, mordant and vat dyes and are manufactured with high purity and precaution to meet the required standards.</td>
</tr>
</tbody>
</table>

**Dyes Intermediate**: Various Dyes Intermediate and their Structure, Methods of Preparation and their Uses is given in Table M-IX 2.4
<table>
<thead>
<tr>
<th>Product</th>
<th>Derivatives</th>
<th>Structure</th>
<th>Method of preparation</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>4-aminobenzene (sulfonic acid)</td>
<td><img src="image1.png" alt="Structure" /></td>
<td>Sulfanilic acid is a grey crystalline solid produced from sulfonation of aniline</td>
<td>It is used to make dyes and sulpha drugs</td>
</tr>
</tbody>
</table>
| N-N-Dimethyl aniline (DMA) | ![Structure](image2.png) | 1. Initially it was prepared by heating aniline and iodomethane. 
2. Industrially it was produced by alkylation of aniline with methanol in the presence of an acid catalyst. | derivative of aniline DMA is a key precursor to commercially important triarylmethane dyes such as Malachite green and Crystal violet |
| Toluene | Ortho chloro Benzoic acid | ![Structure](image3.png) | 1. It may be synthesized by the oxidation of 2-chloro toluene with potassium permanganate. 
2. It can also be synthesized by diazotation which fallsow Sandmeyer reaction. | As an intermediate in manufacture of drugs especially Mefenamic Acid & also in the manufacture of dyes & pigments. |
| | P-Nitro-benzoic acid | ![Structure](image4.png) | 1. It is prepared by oxidation of 4-nitrotoluene using oxygen or nitric acid as an oxidant. 
2. Alternatively it can also be prepared by nitration of ploy styrene fallowed by oxidation of alkyl substituent. | as a dye intermediate, dying carrier, disinfectant additive, penetrating agent and pesticides and manufacturing other compounds |
<p>| | 5-amino-2-chlorotoluene-4-sulfonic acid(C-acid) | <img src="image5.png" alt="Structure" /> | p-toluenesulfonic acid, undergo nitrification followed by reduction so after that filtrate hydrochloride acid was crystallized into 2-amino-5-chloro-p-toluenesulfonic acid | it is an important Intermediate of manufacturing red organic pigments (C.I. Pigment red 48:2) and some dyestuffs. |</p>
<table>
<thead>
<tr>
<th>Naphthalene</th>
<th>α- naphthol (1-naphthol) or 1-Hydroxynaphthalene</th>
<th><img src="image1.png" alt="Structure" /></th>
<th>1. α- naphthol is manufactured by heating 1-naphthalenesulfonic acid with caustic alkali or water under pressure.</th>
<th>directly in making several dyes and converted into numerous dye intermediates, as well as into tanning agents, antioxidants, and antiseptics.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β-naphthol 2-hydroxy naphthalene</td>
<td><img src="image2.png" alt="Structure" /></td>
<td>β-naphthol is manufactured by fusing 2-naphthalenesulfonic acid with caustic soda.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-amino-8-naphthol-4, 6-disulfonic acid (K-acid)</td>
<td><img src="image3.png" alt="Structure" /></td>
<td>1-naphthylamine -4,6,8-3 acid with sodium carbonate solution and in three naphthylamine sodium and at 178-184° C using sodium hydroxide solution for alkali fusion.</td>
<td>As azo dyes, reactive dyes and organic pigments intermediates, mainly used in the production of cationic dyes, reactive red K-2G other</td>
</tr>
<tr>
<td></td>
<td>1-amino-8-naphthol-3, 6-disulfonic acid (H-acid)</td>
<td><img src="image4.png" alt="Structure" /></td>
<td>an important dye intermediate, is produced from naphthalene by a combination of the unit processes of sulfonation, nitration, reduction, and hydrolysis.</td>
<td>H Acid is used in the manufacture of a large number of azo dyes and pigments.</td>
</tr>
<tr>
<td></td>
<td>1-napthyl amine-8 sulfonic acid (Peri Acid)</td>
<td><img src="image5.png" alt="Structure" /></td>
<td>Naphthylamine is an aromatic amine which can be obtained from nitronaphthalene (with iron and hydrochloric acid) or naphthol with sodium acetate, ammonium chloride.</td>
<td>is used directly in making several dyes and converted into numerous dye intermediates, as well as into tanning agents.</td>
</tr>
<tr>
<td></td>
<td>1-napthyl amine-6-sulfonic acid (cleve's acid)</td>
<td><img src="image6.png" alt="Structure" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1-naphthyl amine-7-sulfonic acid (1, 7-Cleve's Acid)</strong></td>
<td><img src="https://example.com/image1.png" alt="image" /></td>
<td>p-toluensulfonic acid, undergo nitrification followed by reduction so after that filtrate hydrochloride acid was crystallized into 2-amino-5-chloro-p-toluenesulfonic acid</td>
<td>it is an important Intermediate of manufacturing red organic pigments (C.I. Pigment red 48:2) and some dyestuffs.</td>
<td></td>
</tr>
<tr>
<td><strong>5-amino-2-chlorotoluene-4-sulfonic acid (C-acid)</strong></td>
<td><img src="https://example.com/image2.png" alt="image" /></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2-napthol-3,6-two sodium salt (R acid)</strong></td>
<td><img src="https://example.com/image3.png" alt="image" /></td>
<td>Its produced from naphthalene by a combination of the unit processes of sulfonation, nitration, reduction, and hydrolysis.</td>
<td>R-salt is an important dye intermediate used in the manufacture of a large number of azo dyes and pigments.</td>
<td></td>
</tr>
<tr>
<td><strong>Anthraquinone</strong></td>
<td><img src="https://example.com/image4.png" alt="image" /></td>
<td>1. It is prepared by reaction of phthalic anhydride and 4-chlorophenol followed by hydrolysis of the chloride. 2. It can also be prepared less efficiently from phthalic anhydride and hydroquinone.</td>
<td>an intermediate for the synthesis of indanthrene- and alizarin-derived dyes</td>
<td></td>
</tr>
<tr>
<td><strong>1,4-diamino anthraquinone</strong></td>
<td><img src="https://example.com/image5.png" alt="image" /></td>
<td>1,4-Diaminoanthraquinone is reacted with sodium dithionite to produce 1,4-diamino-2,3-dihydroanthraquinone.</td>
<td>ananthraquinone dye used with Disperse Red 9 in colored smoke to introduce a violet color. It is also used in dyes and marine flares.</td>
<td></td>
</tr>
</tbody>
</table>

**GAMMA ACID**
Gamma acid belongs to the class of hydroxyl naphthalene mono sulphonic acid is a key intermediate used as diazo and coupling component for the manufacture of commercial dyes belonging to the class of direct, acid, acid-modrant and reactive dyes.

![Chemical Structure of Gamma Acid](image)

**Manufacturing Process:**
G-salt is subjected to Bucherer reaction with liquor ammonia in presence of sodium bisulphite in aqueous solution under pressure in an autoclave to obtain the amido G-salt. Which then subjected to alkali fusion with excesses of caustic soda flakes then neutralized with 40% sulphuric acid to isolate the Gamma acid.

**Chemical Reactions**

\[
\text{G-salt} + \text{NH}_3 + \text{NaHSO}_3 \xrightarrow{} \text{amido G-salt} + \text{H}_2\text{O}
\]

\[
\text{Na}_2\text{SO}_4 + \text{OH} + \text{NH}_2 \xrightarrow{\text{H}_2\text{SO}_4} \text{ONa} + \text{NaHSO}_3 + \text{H}_2\text{O}
\]

**TOBIAS ACID**
Tobias acid is an important dye intermediate belonging to the class of amino naphthalene mono sulphonic acid. It’s used in the manufacture of a number of reactive, direct, acid and acid-mordant dyes.
Manufacturing Process:
Oxy-Tobias acid undergoes amidation by Bucherer reaction in the presence of ammonia, ammonium sulphite and ammonium sulphate. After amidation to bias acid formed in dissolved state as its ammonium salt, then subjected to acidification with sulphuric acid for isolate the Tobias acid.

Chemical Reactions

Metanillic Acid (6-Chloro metanillic acid)
6-Chloro metanillic acid is a key diazo-component used as an intermediate in the manufacture of a variety of direct and acid dyes which are used to dye cotton and wool.
Manufacturing Process:
Ortho nitro chlorobenzene (ONCB) is sulphonated with oleum to afford ONCB para-sulphonic acid (ONCB PSA), then reduced with iron and concentrated hydrochloric acid at 95-100°C in 5 to 6 h. The filtrate is acidified to afford the 6-Chloro metanillic acid which is centrifuged and dried.

Chemical Reactions

\[
\begin{array}{c}
\text{Cl} \quad \text{NO}_2 \\
\text{Cl} \quad \text{SO}_3 \text{H}
\end{array}
\rightarrow
\begin{array}{c}
\text{Cl} \quad \text{NO}_2 \\
\text{Cl} \quad \text{SO}_3 \text{H}
\end{array}
+ 3\text{H}_2
\quad \text{from iron acid}
\rightarrow
\begin{array}{c}
\text{Cl} \quad \text{NH}_2 \\
\text{SO}_3 \text{H}
\end{array}
+ 2\text{H}_2\text{O}
\]

\[
\begin{array}{c}
\text{Cl} \quad \text{NH}_2 \\
\text{SO}_3 \text{H}
\end{array}
+ \text{NaOH}
\rightarrow
\begin{array}{c}
\text{Cl} \quad \text{NH}_2 \\
\text{SO}_3 \text{Na}
\end{array}
+ \text{H}_2\text{O}
\]

\[
\begin{array}{c}
\text{Cl} \quad \text{NH}_2 \\
\text{SO}_3 \text{H}
\end{array}
+ 2\text{mol}
\rightarrow
\begin{array}{c}
\text{Cl} \quad \text{NH}_2 \\
\text{SO}_3 \text{H}
\end{array}
+ \text{H}_2\text{SO}_4
\rightarrow
\begin{array}{c}
\text{Cl} \quad \text{NH}_2 \\
\text{SO}_3 \text{Na}
\end{array}
+ 2\text{mol}
\]

β-NAPHTHOL

β-Naphthol is an important dye intermediate used as a coupling component for manufacture of widely used azo dyes.
Manufacturing Process:
Naphthalene is sulphonated with concentrated sulphuric acid gives naphthalene -1-sulphonic acid. The diluted mass is neutralized with aqueous solution of sodium sulphite containing sodium sulphate.

Chemical Reaction

\[
\text{Naphthalene} + \text{H}_2\text{SO}_4 \rightarrow \text{Naphthalene-SO}_3\text{H} + \text{H}_2\text{O}
\]

\[
\text{Na}_2\text{SO}_3 + \text{Naphthalene-SO}_3\text{H} \rightarrow \text{Naphthalene-SO}_3\text{Na} + \text{H}_2\text{O}
\]

ANTHRAQUINONE -1- SULPHONIC ACID SODIUM SALT
9, 10-Anthraquinone and all its derivatives are important building block for a variety of dyestuffs, in particular for disperse, solvent and acid dyes.

Manufacturing Process:
Phthalate anhydride is treated with benzene in excess of the AlCl3 as a catalyst gives ortho-benzoyl benzoic acid (BOB) in form of Al complex. BOB future subjected to cyclization and sulphonation using in the presence of HgO as a catalyst to obtain anthraquinone-1-sulphonic acid.
Chemical Reactions

Anthraquinone - 1-sulphonic acid Sodium salt

Anthraquinone + Benzene → COOAlCl₂ + HCl

H⁺ + H₂O → H₂O

Anthraquinone + BOB → H₂O

HgO + SO₃ → SO₃H

Anthraquinone - 1-sulphonic acid Sodium salt
ANTHRAQUINONE -1- SULPHONIC ACID AMMINIUM SALT

Manufacturing Process:
Mercury is heated into 20% oleum at 80°C for 3 h then anthraquinone (AQ) is heated at 130°C for 3 h to complete sulphonation of AQ after filtration the filtrate neutralize with ammonia and after cooling 30°C precipitate out anthraquinone -1- sulphonic acid ammonium salt.

Chemical Reactions

\[
\text{Hg} + \text{H}_2\text{SO}_4 \rightarrow \text{HgSO}_4 + \text{H}_2
\]

Anthraquinone + \text{SO}_3 \xrightarrow{\text{HgSO}_4, \text{ClSO}_3\text{H}} \text{Anthraquinone - 1-sulphonic acid Ammonium salt}

\[
\text{Anthraquinone - 1-sulphonic acid Ammonium salt}
\]

Anthraquinone - 1 -sulphonic acid Ammonium salt
RESORCINOL

Resorcinol is a key dyestuff intermediate widely used as a coupling component for a variety of azo dyes belonging to various classes such as direct, acid, reactive and disperse dyes. It is also an important monomer for the production of polymers especially polyesters. Derivatives of resorcinol have also found use as sun screen agents and UV stabilizers.

\[
\text{OH} \quad \text{C}_6\text{H}_4(\text{OH})_2
\]

Manufacturing Process:

Benzene is sulphonated using liquid sulphur trioxide in presence of sulphuric acid and sodium sulphate. The benzene disulphonic acid (BDSA) is converted to its disodium salt using soda ash, which then treated sulphuric acid then resorcinol is extracted with butyl acetate.

**Chemical Reaction**

\[
\text{C}_{6}\text{H}_{4}(\text{OH})_2 + 2 \text{SO}_3 \rightarrow \text{C}_{6}\text{H}_{4}(\text{SO}_3\text{H})_2 + \text{Na}_2\text{CO}_3
\]

\[
2 \text{H}_2\text{O} + 2 \text{Na}_2\text{SO}_3 + \text{SO}_3\text{Na} + \text{H}_2\text{SO}_4 \rightarrow \text{C}_{6}\text{H}_{4}(\text{SO}_3\text{Na})_2 + \text{Na}_2\text{SO}_4
\]

\[
\text{C}_{6}\text{H}_{4}(\text{SO}_3\text{Na})_2 + 4\text{NaOH} \rightarrow \text{C}_{6}\text{H}_{4}(\text{ONa})_2 + \text{H}_2\text{O} + \text{CO}_2
\]
**DARK BLUE BO:** Dark blue (BO) is a vat dye containing two or more keto groups which has great affinity for cellulosic fibre.

![Chemical structure of Dark Blue BO](image)

**Violanthrone**

**Manufacturing Process**
Naphthalene and sodium acetate with molten mixture of NaOH and KOH are added in 1.25h at 185°C then crude benzanthrone heated over 4 h at 235°C. The dye which separates out is filtered off through filter press and wash well with hot water.

**Chemical Reaction**

![Chemical reaction diagram](image)
REFERENCES

1. Annual Report 2011-2012, Department of Chemical and Fertilizers, Govt. of India
4. CPCB, 2004 “Identification of hazardous waste streams, their characterization and waste reduction options in Dyes and dye intermediate sector”, Central Pollution Control Board MOEF ,New Delhi, August, 2004
Kavavadze et al., 2009