

Water pollution: Dyeing of fibers

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Abstract

It is well known that a large quantity of water is used in dyeing process of fibers. Water resources (rivers, lakes, underground water etc.) are polluted to a major extent by textiles industries. In these a large number of process occurs which uses water in huge quantity for washing, bleaching etc. In dyeing process, a large volume of water is used and when it mixed with other water resources it pollutes that water also which affects the human as well as aquatic life. A large number of the methods are used to check purity of water, some of them are pH, COD (chemical oxygen demand), BOD (biological oxygen demand), TDS.

Keywords: water pollution, dyes, fibers

Introduction

Water pollution is a big threat to our environment. Around 71 percent of earth surface is covered with water in which 96.5 percent water is saline and thus only 3.5 percent water is available for drinking purpose which is called potable water. Textile industries pollute water system to a major extent. In textile industries a number of processes occur which use water for washing, to colorize or decolorize fibers, bleaching etc. A large quantity of water is used in dyeing process of fibers.

Textile industries are divided into two steps: wet fabric industry and dry fabric industry. In wet fabric industry water is used in large volumes for a number of processes such as sizing,

desizing, scouring, bleaching, mercerizing and dyeing. Sizing is a process in which strength of fibers is enhanced by adding some chemical substances such as starch, polyvinyl alcohol etc. which are called sizing materials. After sizing desizing is a process in which sizing materials are removed from fibers. In scouring process an alkaline solution is added to remove impurities. In bleaching sodium hypochlorite and hydrogen peroxide are added to remove unwanted colors. In mercerizing concentrated alkaline solution is added to increase lustre, dyeability and fiber appearance. Dyeing is a last step in which colorization of fibers occurs by adding sufficient dyes into it. This is the process in which a large volume of water is used.

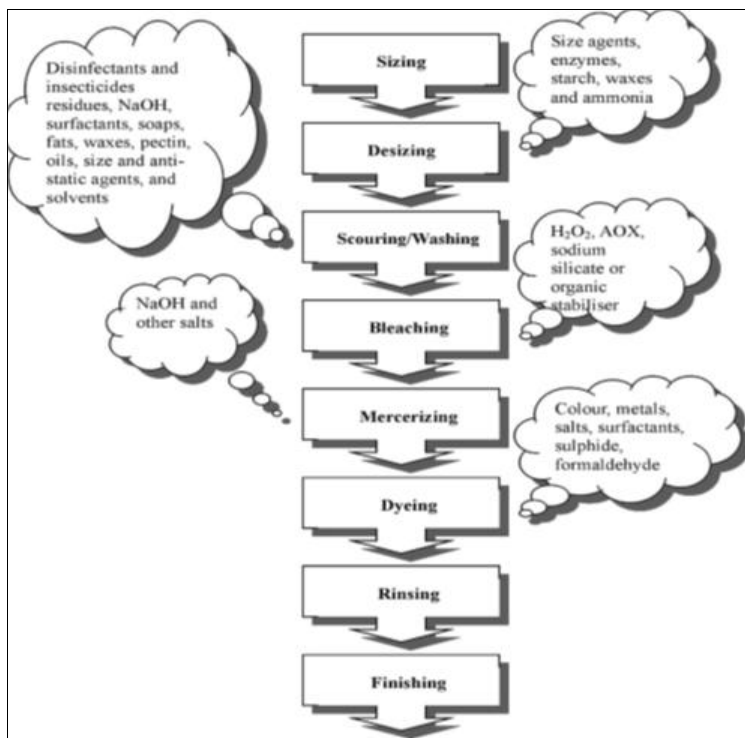


Fig 1: Different process and chemicals used in textile industry.

Dyes

Dyes are chemical compounds which exhibit color to fiber, textile, paper etc. majorly in aqueous medium. These have autochromes and extended resonance so that their spectra lies

in the visible region and show a specific color. In auxochromes different functional groups are present such as azo, carbonyl, nitro, hydroxyl etc.

Table 1: Electromagnetic spectrum

Electromagnetic region	Wavelength (nm)	Color
Ultra violet	Less than 350	Colorless
Visible	350–400	Not defined
	400–435	Violet
	435–480	Blue
	480–490	Greenish-blue
	490–500	Bluish-green
	500–560	Green
	560–580	Yellowish-green
	580–595	Yellow
	595–605	Orange
	605–750	Red
Infrared	750–780	Not defined
	More than 780	Colorless

A number of dyes are present which show specific colors because of their specific absorption spectra.

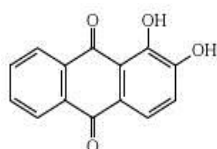
In ancient era dyes are manufactured majorly from natural sources such as tree, vegetables, insects etc. there are a number of

methods in ancient era to extract colors from dyes but these are tedious work because some of these naturally occurring dyes are not so stable. Some of these naturally occurring dyes and sources of these dyes are listed in table 2 below.

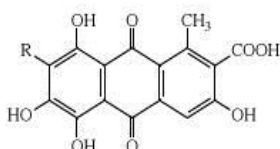
Table 2: Different types of natural dyes and their sources

Name	Extracted from (source)	Color	Class
Tyrian purple	Mollusks, <i>Murex brandaris</i>	Purple	Indigoid
Indigo	<i>Indigofera tinctoria</i> L., indigo plant leaves	Blue	Indigoid
Logwood	<i>Haematoxylon campechianum</i> L., heartwood	Black	Chroman
Alizarin	Madder plant roots, <i>Rubia tinctorum</i>	Red	Anthraquinone
Kermes	Insects, <i>Coccus ilicis</i>	Red	Anthraquinone
Cochineal	Insects, <i>Dactylopius coccus</i>	Red	Anthraquinone
Safflower	Dried petals of <i>Carthamus tinctorius</i>	Yellow	Flavonoid
Quercetin	North American oak bark, <i>Quercus tinctoria nigra</i>	Yellow	Flavonoid
Weld	Seeds, stems, leaves of <i>Reseda luteola</i>	Yellow	Flavonoid

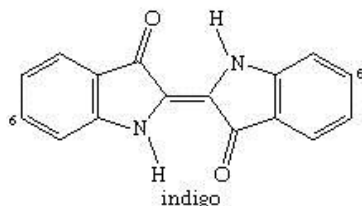
Structures of some commonly used dyes are



alizarin



kermesic acid (R = H)
carminic acid (R = glucosyl)



indigo

Mordants

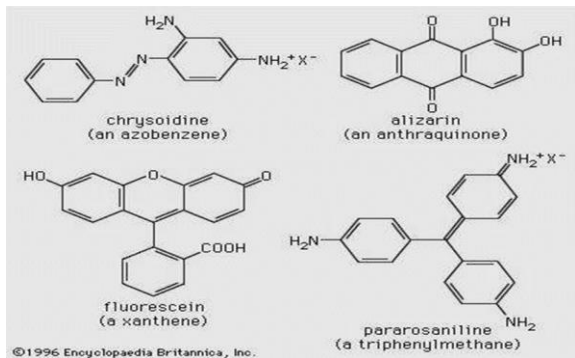
Natural dyes are not used as such to colorize cotton or fibers but some compounds are added to these dyes and these compounds are called mordants. Some of the ancient mordants are alums, salts of iron, copper, tin etc. these mordants bind with fibers and adsorb dyes onto it and thus colorization of fibers occurs.

Different colored dyes were also prepared in ancient time by mixing two or three different dyes and thus a dye with different color is obtained. Metal salts were also added to

enhance the color of dyes.

Synthetic dyes

By the time use of dyes increased and because natural dyes are not so stable and these are not enough for fiber industries a number of dyes were synthesized and these are called synthetic dyes. Due to development in research of chemical bonding, spectra a platform for synthetic dyes with a specific color arises. Some of the synthetic dyes are



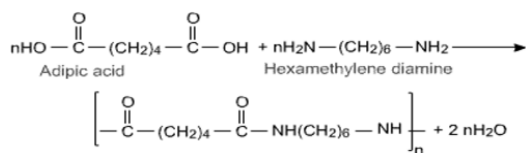
Fibers are prepared by various spinning techniques so that bundles of fibers obtained which have large number of fibers coiled. There occur submicroscopic pores in fibers which are responsible for dyeing of a fiber.



Fig 2

Fibers

Fibers are polymeric chains compounds in which mainly amide linkage (-CO-NH-) are found. For e.g. wool, silk, leathers, nylon, cellulose etc.



Nylon 6,6

Dyeing

In dyeing process of a fiber there occurs chemical reactions which may form covalent bonding, hydrogen bonding, Van der Waals forces, solubilities etc. between dye and fiber. Dyeing process is divided into various techniques which are listed below

Table 3: Different techniques of dyeing

Name of technique	Procedure	Examples
Direct dyeing	In this technique direct solution of dyes are applied to hot aqueous solution of fibers.	Naturals dyes
Disperse dyeing	These are mainly used for hydrophobic fibers in which direct dye solutions are not applied. Therefore, in this techniques dispersion of dyes from aqueous solution to fibers occurred.	Used to dye acetate rayon, PET, and acrylics
Vat dyeing	This process is done outdoors in large containers. In this dyeing process conversion of a soluble species to insoluble dye after transfer to the fiber.	Indigo dyes are converted to soluble leucoindigo
Azo dyeing	In this techniques diazotization (-N=N-) of amino bonds occurred by reacting with nitrous acid.	Azo dyes, congo dyes
Reactive dyeing	In this a chemical reaction occurs between dye and fiber.	C.I. Reactive Blue 19, C.I. Reactive Red1

Water pollution

In dyeing process, a large volume of water is used and these when mixed with other water resources it polluted that water also which effect the human as well as aquatic life. In India a number of methods are used to check purity of water some of them are pH, COD (chemical oxygen demand), BOD (biological oxygen demand), TDS, sulphide, chlorides etc. Chemical oxygen demand is a parameter to measure quality of water in this amount of oxygen consumed due to oxidation of organic water contaminants to inorganic by products. And in biological oxygen demands (BOD) amount of oxygen which is needed for the biological degradation of organic substances in water in mg O₂/l is measured. The optimum value of different pollutants in water are listed in table 4.

Table 4

S.no.	Parameters	Standards
1	COD	250 ppm
2	BOD	30 ppm
3	pH	6.9
4	TDS	2000 ppm
5	Chloride	500 ppm
6	Sulphide	2 ppm
7	Calcium	75 ppm
8	Magnesium	50 ppm

Water pollution caused by the textile industry is also a major cause of concern. Boilers, thermo pack, and diesel generators produce pollutants that are released into the water resources. Due to dyeing process and washing of these fibers uses a large volume of water and thus a number of chemicals compound present on chain of fibers or in dyes or in mordants released in water resources which causes water pollution. Waste water managements relying on activated sludge systems are not adequate for the treatment of textile mill effluents, neither on site nor after dilution with domestic wastewater at the sewage works. Decolorization of fibers may be done by using many biological phenomena such that these may degrade pollutants molecules. There, is a requirement to find the various research methods which considers the above effects. Such a study must apply analytical tools to estimate the effect of the chemical oxidation process as a pre-treatment or post-treatment on harmfulness and ratio of BOD to COD i.e. biodegradability index. Thus, the effect of pretreatment or post treatment should not be only evaluated by ratio of BOD to COD but also toxicity of intermediates obtained after treatment as toxicity may give very low COD but cause big damages.

Conclusion

From the study of dyeing process of fibers, it has been

concluded that the large amount of water is used in washing, bleaching etc. Measurement of BOD, COD, PH are the methods used to check the quality of water. Some of the mordants mixed with natural dyes and some of synthetic dyes are used to colorize cotton or fibers.

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