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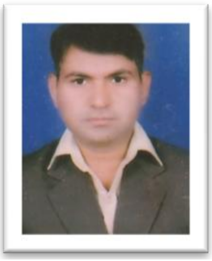
Environmental and Health Effects of Textile Dye



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Abstract

Textile mills are major consumers of water and consequently one of the largest groups of industries causing intense water pollution. The extensive use of chemicals and water results in generation of large quantities of highly polluted wastewater which is not only harmful for aquatic life but also mutagenic to human.

Keywords: Azo-Dyes, Textile Industry, Environmental Impacts, Health Impacts, Waste Water Techniques

Introduction

Textile processing employs a variety of chemicals, depending on the nature of the raw material and products. It is estimate that about 10 % of the chemicals are lost in industrial wastewater. The wastewater generated by the different production steps (i.e. sizing of fibers, scouring, desizing, bleaching, washing, mercerization, dyeing and finishing) has high pH and temperature. [1] It also contains high concentration of organic matter, non-biodegradable matter, toxic substances, detergents and soaps, oil and grease, sulfide, sodas, and alkalinity. In addition, the high salt conditions of the reactive dye baths result in high-salt wastewater, which further exacerbates both their treatment and disposal. The fate of these chemicals varies, ranging from 100% retention on the fabric to 100% discharge with the effluent. As a result, textile industry is confronted with the challenge of both color removal and effluent salt content reduction. In addition, reactive dyes are highly water-soluble and non-degradable under the typical aerobic conditions found in conventional biological treatment system [2]

Synthetic dyes are indispensable to the textile and dyeing industries. Fashion would not have so much color and arouse so much interest were it not for the effects of such dyes. Among all synthetic dyes, azo dyes are the most common, being used up to 90 per cent of the time, because they are versatile and easy to synthesize. Yet many azo dyes are toxic and may cause genetic mutations, and because they are synthetic, the natural environment cannot recognize them or degrade their toxicity.

Though man has invented sewage treatment plants to deal with different kinds of man-made sewage, technology as it is now is unable to degrade the toxic components of azo dyes. Even a very low concentration of these dyes in industrial effluents is enough to do great damage to the environment.

Aim of the Study

The aim of this work is to give an overview on the health and environmental impact of dyes as pollutants as well as; the most recent treatment techniques Transformation of Azo-Dyes in the presence of Methylene Blue immobilized Resin Dowex-11 photo catalyst of textile effluents wastewater.

Health and Environmental Impact of Dyes

The mostcommon hazard of reactive dyes is respiratory problems dueto the inhalation of dye particles. Sometimes they can affect aperson's immune system and in extreme cases this can meanthat when the person next inhales the dye their body can reactdramatically. This is called respiratory sensitization andsymptoms include itching, watery eyes, sneezing andsymptoms of asthma such as coughing and wheezing [3].Perhaps the most predominant health problems related todyeing and finishing processes arise from exposure tochemicals acting as irritants. These may cause skin irritation, itchy or blocked noses, sneezing and sore eyes. They includeformaldehyde-based resins, ammonia, acetic acid, someshrink-resist chemicals, some optical whiteners, soda ash,caustic soda and bleach. Certain reactive, vat and dispersedyes are also recognized as skin sensitive

Textile industries produce large amounts of liquid wastes. These textile effluents contain organic and inorganic compounds. During the dyeing processes, not all dyes that are applied to the fabrics are fixed on them and there is always a portion of these dyes that remains unfixed to the fabrics and gets washed out. These unfixed dyes are found to be in high concentrations in textile effluents [4].

The amount of water consumed and released also varies depending on the type of fabrics produced. Almost 0.08 – 0.15 m3 of water is used to produce 1 kg of fabrics. It is estimated that about 1,000 – 3,000 m3 of water is let out after processing about 12 – 20 tons of textiles per day. These effluents are rich in dyes and chemicals, some of which are non-biodegradable and carcinogenic and pose a major threat to health and the environment. Several primary, secondary and tertiary treatment processes like flocculation, trickling filters and electrodialysis have been used to treat these effluents. However these treatments are not found effective against the removal of all dyes and chemicals used. The effluents do not only contain high concentration of dyes used in the industry, but also contain the chemicals used in the various processing stages. Some trace metals such as Cr, As, Cu and Zn are present in these effluents and are capable of causing several health problems including haemorrhage, ulceration of skin, nausea, severe irritation of skin and dermatitis. Textile effluents are also found to contain other organic and microbial impurities [5-6]. The usage of cotton has been increasing constantly throughout the past century. Cotton fibres are mainly dyed using azo dyes which are one of the largest groups of synthetic colorants used in the industry. Azo dyes are difficult to degrade by the current conventional treatment processes. They are characterized by the presence of the nitrogen-nitrogen bond (-N=N-) in the center and hence they are highly electron deficient [7].

These azo dyes are found to be complex in nature and have been found to show carcinogenic evidences on reductive cleavage. These dyes are capable of altering the physical and chemical properties of soil, deteriorating water bodies and causing harm to the flora and fauna in the environment [8]. It was observed that the toxic nature of dyes causes death to the soil microorganisms which in turn affect the agricultural productivity.

The presence of very small amount of Azo dyes in water (<1ppm) are highly visible. This affects aesthetic merit, transparency and water-gas solubility. Reducing light penetration through water decreases photosynthetic activity, causing oxygen deficiency and de-regulating the biological cycles of aquatic biota. Many Azo dyes are also highly poisonous to the ecosystem and mutagens, meaning they can have acute to chronic effects upon organisms, depending on exposure time and Azo dye concentration. 1,4-diamino benezene is an aromatic amine whose parentazo dyes can cause skin irritation, contact dermatitis, chemosis, lacrimation, exopthamlmose, permanent blindness, rhabdomyolysis, acute tubular necrosis supervene, vomiting gastritis, hypertension, vertigo and, upon ingestion, oedema of the face, neck, pharynx, tongue and larynx along with respiratory distress. Aromatic amines can be mobilized by water or sweat, which encourage their absorption through the skin and other exposed areas, such as the mouth. Absorption by ingestion is faster and so potentially more dangerous, as more dye can be absorbed in a smaller time frame [9]. Water soluble Azo dyes become dangerous when metabolized by liver enzymes.

My present work, transformation of industrial importance compounds (Azo-Dyes), in the presence of Methylene Blue immobilized Resin Dowex-11 photo catalyst, these dyes are large part of water pollutant in textile effluent and results of transformation is better than other transformation processes which are carried out earlier for transformation of azo dyes[11].

Methylene Blue immobilized Resin Dowex-11 is a heterogeneous photo catalyst. In heterogeneous photo catalyzed systems, photo induced molecular transformation occurs or reaction takes place at the surface of a catalyst. Depending on where the initial excitation occurs, photo catalysis can be generally divided in to two classes of process. When the initial photo excitation occurs in adsorbate molecule, which then interacts within the ground state of catalyst substrate, the process is referring to as a catalyzed photoreaction. When the initial photo excitation takes place in the catalyst substrate and the photo excited catalyst transfer its electron or energy to a ground state molecule, the process is referred to as a sensitized photoreaction.

Treatment of Metal Ions Present in Textile Wastewaterte

Textile industries generate wastewater that contains considerable amount of non-fixed dyes. Dye pollutants produced from the textile industries are also becoming major sources of environmental contaminations. In case of India, there are many engineering, chemical, mineral, dyes, gem, plastics, oil, rubber, and pulse industries but textile processing industries are far numerous. The textile industry consumes considerable amount of water during the dyeing & finishing operations. Considering both volume discharge & effluents composition, the wastewater generates by the textile industry is rated as one of the most polluting among all industrial sectors.

It is estimated that about 15% of the total world production of dyes is lost during the dyeing and finishing operations and is released in the textile effluents. Azo dyes which contains one or more nitrogen to nitrogen double bonds (-N=N-) and constitute a significant portion of dye colorants, are widely used in the dyeing industry today [12]

Azo-dyes; which contains one or more azo-bonds are coming the most widely used synthetic dyes and usually are major pollutants in dye waste water these azo-bonds are so strong and are therefore difficult to break and hence there azo-dyes are non-biodegradable & are toxic. Owing to their toxicity and slow degradation, these dyes are categorized as environmentally hazardous materials. The discharge of this coloured, toxic and non-biodegradable wastewater in the ecosystem has been problematic.

Transformation of Azo-Dyes in the presence of Methylene Blue immobilized Resin Dowex-11 Photo Catalyst

Preparation of Photo Catalyst

We prepare approximately M/1000 concentration solution of Methylene Blue in Double distilled water and add Dowex-11 resin in this solution and shake well. Put this mixture for 3 days for complete immobilization of Methylene Blue Inside the pores of resin. All the process is carried out in dark place. After three days we can filter Methylene blue immobilized resin from solution, wash this resin by double distilled water twice and used it as photo catalyst.

Role of Methylene Blue

Methylene blue is photosensitized dye. When molecule of Methylene Blue immobilized in pores of resin (fill in pores of resin). Methylene blue is photosensitized dye and becomes exited by absorbing photons of light radiations. In first electronic excitation, electron transfers into singlet state and through inter system crossing (ISC) electron can transfer to triplet state of Methylene Blue. Further inter molecule electronic interaction occurs between resin, Methylene blue and solution mixture and resultant is formation of holes, hydroxyl radicals and Supra oxide ions (o^-), these are highly oxidative in nature [13].

Analytical Methods

The change in dye concentration is observed simply by Shimadzu-160 UV/Visible spectrophotometer. We suck out 10 ml of solution by pipette at the time interval of 15 minutes and observe changes in percentage transparency of dye solution.

The mechanism of this process is as follows-

Result and Discussion

Probable Chemical Reaction of This Degradation

Methylene Blue Immobilize Resin Dowex-11. This is newly developed photo catalyst. The dye immobilize in porosity of resin is Methylene Blue. Methylene Blue is photo sensitive in nature, when light radiation is irradiated on it electronic transition occurs from valance band (VB) to conduction band (CB) and through intersystem crossing (ISC) electron reach in to triplet state of Methylene Blue.[14-15] After it intermolecular electronic transition start between resin, Methylene blue dye molecules, water molecules, Tropaeolin O dye molecules and dissolved oxygen, resultant through chain process, holes, hydroxyl radicals and Supra oxide ions (o^-) are produced and these are highly oxidizing in nature, by the action of holes, hydroxyl radicals and Supra oxide ions (o^-) on Azo dyes, are transformed in simple organic compounds like CO_2, H_2O, SO_2, N_2, etc.

The main factors influencing the photo catalytic degradation of Azo dyes is variation in catalyst loading, variation in concentration of dye, variation in pH of the solution, variation in light intensity, variation in dissolve oxygen.

The generation of holes, hydroxyl radicals and Supra oxide ions (o^-) can be explained better with the help of proposed diagram. This proposed diagram shows the action of photo catalyst and process of generation of oxidative intermediates [16-17]

Mechanism

On the basis of the observed data, the following tentative mechanism may be proposed for photocatalytic degradation of Azo Dye

$$\text{Dye} \xrightarrow{\text{Light Radiations}} \text{Dye}^{*1}$$

$$\text{Dye}^{*1} \xrightarrow{\text{ISC}} \text{Dye}^{*3}$$

$$\text{Dye}^{*3} + \text{I-R} \longrightarrow \text{Dye}^{+} + \text{I-R}\ (e^-)$$

$$\text{I-R}\ (e^-) + O_2 \longrightarrow \text{I-R} + {}^-O_2$$

$$\text{Dye}^{+} + {}^-\text{OH} \longrightarrow \text{Dye} + {}^\bullet\text{OH}$$

$$\text{Dye} + {}^\bullet\text{OH} \longrightarrow \text{Product}$$

When the solution of the dye was exposed to light, in presence of photo catalyst, initially the Dye molecules are excited to first excited singlet state (Dye $*^1$). Then these excited molecules are transferred to the triplet state through inter system crossing (ISC). The triplet dye (Dye $*^3$) may donate its electron to the photocatalyst and the dye becomes positively charged [18]. The dissolved oxygen of the solution will pull an electron from the conduction band of the semiconductor, thus, regenerating the semiconductor.

The positively charged molecules of the dye (Dye^+) will immediately react with OH^- ions to form $OH^\bullet$ radicals that will convert the dye molecules into products[19-20].

Conclusion

As compared to solar photo catalytic systems with other photo catalyst, Methylene Blue immobilized-Resin Dowex-11used as solar photo catalysts gives very good results and successfully improved the degradation rate of organic dyes. It believed that the improved color degradation capability is due to the fact that the visible region of the solar radiation excites the Methylene blue immobilized resin, followed by a series of photosensitizing reactions. The photo catalytic degradation of Azo Dye has been studied using Methylene Blue immobilized-Resin Dowex-11 as photo catalyst. The photo catalytic degradation of the dyes follows first order kinetics for the system.

The photo catalytic degradation efficiency has been generally, found to increase with increase in catalyst loading. The Photo catalytic transformation decreases with increases in initial dye concentration. With the increase in the concentration of a dye solution, the number of photons decreases, to reach the catalyst surface, decreasing the number of photons absorbed by the catalyst and all the degradations occur at an optimal pH 7.5 value.

Therefore this technology has very good potential of organic molecular degradation from complex molecule into simpler molecules. Azo dyes which polluted water large part of textile effluent can transform into color less and nontoxic compounds so this catalyst may applicable for industrial purpose for improvement in quality of the wastewater of textile industries and many others.

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