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Chemical Color Stripping of Cellulose Fabric dyed with Reactive dyes

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ABSTRACT

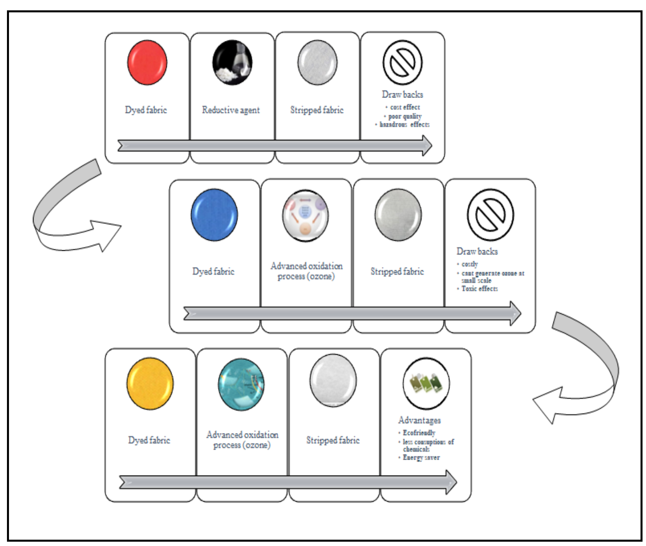
Chemical color stripping is an operational technique to overcome different hue faults during the dyeing process. Conventionally, the stripping methods implicate high bathing ratios, temperatures and loads of chemicals due to which the fabric strength decreases significantly and these methods were high in cost due to high energy consumptions. Many methods to sort out these faulty dyeing of fabrics has been adapted, such as destructive stripping and desorption stripping etc. In this article, three different techniques have been discussed such as conventional methods of reductive color stripping and advanced stripping methods as oxidative and photo-catalytic color stripping. The purpose of this article is to review the color stripping methods by comparing the color stripping efficiency of these methods which was evaluated by using different parameters such as time, effect of pH, loss in weight and strength of the fabric during the stripping process and the pilling resistance. The results obtained from these methods demonstrated that the conventional method of reductive stripping affects the crystalline of the fabric, harmful towards humans due to the use of harsh chemical usage, time and energy consuming. Furthermore, the oxidative method of stripping found was more efficient as compared to reductive one due to less consumption of energy, water and chemicals. Besides, all of these are novel techniques i.e., photo-catalytic is found to be finest among the all cited techniques as it is more energy conserving and eco-friendly than the others. After stripping the white cellulose fabric moves towards recycling, this helped to overcome the need for textile by giving the astonishing look to the fabric. This article basically highlights the significance of stripping processes and their limitations by providing the opportunities for the new researchers to develop more effective, less time consuming and more energy saver dyeing and stripping procedures to tackle these problems.

Key words: Stripping, types of stripping, chemical stripping, Reductive Stripping, Advance Oxidative stripping, photo-catalytic stripping, recycling

Introduction

The growth of the world's population, along with the lifestyle and fashion culture revolutionized that led to an increase in demand for textile fabrics. Regarding coloring and dyeing process undesirable errors and accidents occur like color dots, different color hues and off-shade etc. which significantly decrease the fabric quality and value (Oğulata and Balci 2007).

These dyeing faults could be rectified according to their severity by various methods like direct leveling, lightening with auxiliaries re-dyeing in deeper shades, or color stripping, etc. In most cases, the dye products, however, often show significant color differences, especially some bright colors, that are incompatible with product standards (Long et al., 2010). In such cases, a color stripping procedure is used to correct the faultily dyed most of the time. It has been studied by different scientists around the globe that stripping method is the most effective method of recycling the defective dyed fabrics (Määttänen et al., 2019).



In this article various stripping methods, their efficiency and recycling of effluents was discussed in detail to find out the most effective technique which was cost effective and eco-friendly. As stripping efficiency and their behavior depend on various factor, listed below

1) Which type of stripping agent and auxiliaries was applied?
2) Sources/ Raw material
3) Type of dyestuff (disperse dye, reactive dye, sulfur dye)
4) Method and mechanism of dyeing & stripping
5) Quality and type of fabric (cotton, silk, polyester)
6) Working parameters (Time, Temperature, pH)

All these features are very important to achieve most reliable and effective stripping performance (Oğulata and Balci 2007). This review is basically focused on all these features and how these features affect the quality of the fabric. How we can improve the quality of fabric. As we know stripping is undoubtedly a degradative process in which adverse conditions and rasping chemicals are applied on fabric so high consumption of auxiliaries and water are being used during stripping, which cause a serious risk of environmental pollution. Therefore it is impossible to avoid the unfavorable effects on quality of substrate material but could be minimized to a tolerable range by developing a cost effective techniques with the nature of eco-friendly, usage of less chemical, time and temperature (Neppolian et al., 2002; Chatha et al., 2012; Xu et al. 2015; Long, et al., 2017). Moreover, Stripping method decrease the quality of the fabric, and effluents generated from the fast fashion sector (Bigambo et al., 2020) investigated that, these effluents was not capable to regenerate This researcher are looking for the other ways like landfill/ incineration and recycling. On the other hand, landfill and incineration of the effluents accompanying the environmental pollution, whereas recycling of the effluents of the textile with the presence of dye and fiber gives the low-value product (Morley et al., 2006; Wang 2006).

Chemical recycling of the cotton effluents also limited due to presence of dyes which form the cross linking –OH bond with fiber and dyes which in turn reduced the suspension of the cellulosic raw-material. Which in turn reduce the spinning of recycled fabric and thus affect the properties of the renewal fabric (Abhyankar et al., 1985; Abhyankar et al., 1987; Rigout et al., 2014; Vickers 2017). Therefore it's necessary to strip off the fabric that ruptures the covalent bond and cross linking agent from the surface of the fabric which gives us the better results during the recycled process.

Brief description of Stripping

Color stripping is also known as the decolorization/degradation process. So it is the process of removing the uneven and faulty dyes from the fabric. The stripping methods are divided according to types of dyestuff or types of fabric to be stripped and the effects of stripping on the dye molecules in the substratum matrix. This includes Extraction stripping, Destructive stripping, and Desorption stripping.

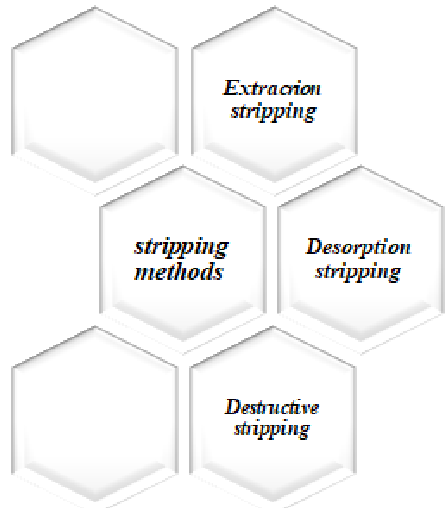


Fig 1: Types of chemical stripping

Destructive stripping applied through a sequence of chemical reactions results in disintegrating of the molecular structures of dye molecules (Körlü 2018). However, during destructive stripping, the color of the dye construction could dies under high temperature and alkaline or acidic environment, which usually uses certain reducing and oxidizing agents, such as sodium sulphite, rongalitis, decroline, thiourea dioxide and hypochlorite, chlorine dioxide, hydrogen peroxide, etc. As a result, the destructive color stripping process usually involves several harmful chemicals, higher temperatures, and variability in pH values, which quickly lead to the release of a high number of toxic effluents into the water supply and serious environmental problems could be resulted (Long et al., 2015).

The second was desorption stripping, where some form of solvent and surfactant was dissolved from colored substrates without de-constructing the dye conjugated system. During the extraction process of stripping, the color structure themselves has a negligible impact (Mu et al., 2019) where solvents and other extracting agents have a higher affinity for the dye molecules which was primarily used for the extraction and removal of colored molecules into an appropriate solution.

The destructive color stripping method was the most commonly used in actual manufacturing and fabrication (Neppolian et al., 2002). Furthermore, this ordinary and extensively used strategies usually involves extreme doses of numerous agent that is to say reducing and oxidizing agents, high bathing ratio, temperatures and many chemical substances that pose a significant risk of contamination of the environment with high water consumption and cost (Oturan and Aaron 2014).

Therefore it is very important to establish such an efficient removal technology with low temperature and high-performance methods to remove faulty and defective colors. Depending on the type and nature of the fabric to be stripped, it must be developed individually. Chemical stripping is the best procedure adopted by most of the textile industries because of its simple processing, user friendly and less time consuming. One of these four methods are commonly used to achieve the complete chemical stripping (Aspland 1997; Fono 1980).

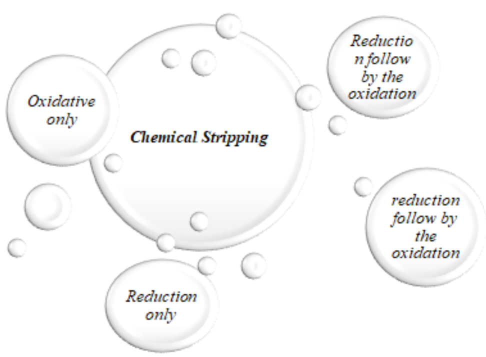


Fig 2: Methods of chemical stripping

Now a days, the researcher working on the photo-catalytic strategy and it was successfully functioning in industrial sectors during the water waste treatment (Neppolian et al., 2002), purification of the air, in the self-cleaning application of the fabric (cotton) (Xu et al., 2015). Different scientists on the globe are also working on the photo-catalytic stripping and effective results were obtained during this process.

In this article the detailed study of oxidative, reductive color stripping, photo-catalytic color stripping and recycling of waste fabric was discussed. After stripping the white cellulosic fabric is used as a raw-material for the renewal of the fabric. In which oxidative color stripping was carried out in the presence of ozone. Whereas reductive color stripping was carried out in the presence of sodium hydrosulphite. Photo-catalytic stripping was conducted by employing the irradiation of TiO 2.

The aim of this article is to find the most efficient stripping technique among them.

i. Reductive Color Stripping
ii. Oxidative Color Stripping
iii. Photo-catalytic Color Stripping

Reductive Color Stripping

Reductive stripping is the type of chemical color stripping reaction. Method and mechanism of reductive stripping depends on the quality of the fabric, type of dye and. The fabric is dyed through dispersed dye, reactive, azo, anthraquinone or sulfur dye. Traditionally a dyed fabric was stripped with the help of reducing agents and their efficiency can be enhanced through the stripping assistant (a chemical which is used during the reductive process to enhance their efficiency). A series of reducing agent, stripping assistant and their chemical combination are available to strip/decolorize a dyed fabric (Chung et al., 2004).

In order to decolorize the cellulose fabric dyed with reactive dye a chemical reaction occurs between the chemical bonds on the chromophoric groups of reactive dyes. It is very difficult to strip a cellulose fabric dyed with reactive dye due to formation of covalent bond between the fabric and dye. In 1956 these dyes were first introduced by Stephens and Rattee at the Imperial Chemical Industries. Reactive dyes are the well-known class of the advanced synthetic dyes. The purpose behind this success lies behind the flexibility in hues, very good color-fastness and wash-fastness properties with the brighter color. If these dyes are applied properly, the color does not fade but is damaged when the fabric comes in contact with bleach or chlorine (Uddin et al., 2015).

Reactive dye colors the cotton, cellulose, rayon, nylon etc. through substitution or additional reaction by the combination with the fabric stuff. They react directly with the substrate of the fabric and dyes by forming the covalent bond and these bonds are stable when they come in contact with laundering conditions (Long et al., 2015).

Fabric + Reactive dyes = reactive dyed-fiber (forming covalent bonding)

The protocol of reductive stripping depends on the type of fabric, dye and stripping agents (Choudhury, 2006). Here I discussed one of the reductive stripping methods and reviewed their efficiency by evaluating its working parameters and other effects. Reductive agent i.e. caustic soda and sodium hydrosulphite was used with the varied concentration detail was mentioned in (Uddin et al., 2015). The fabric was dyed with 2.5% and 5% shades and then stripped by following the reductive mechanism of stripping. From the paper it was investigated that stripping efficiency was enhanced with the increase in concentration of caustic and hydrose. The temperature also influenced the rate of stripping percentage i.e. maximum stripping percentage was at 100oC as compared to 80o C. The stripping percentage can enhance by increasing both the concentration and temperature to get better results.

Strength loss& Weight Loss

Quality of the fabric assessed through the loss in strength and weight of the fabric. Based on the alkali reductive process it was noted that as the concentration of stripping chemicals, stripping bath and temperature increase in the similar trend the percentage of fabric strength loss increases. Such as when fabric treated with 10g/L caustic and hydrose having 2.5% and 5% shades at 100oC we find the maximum strength loss of 9.23% and 10% (Uddin et al., 2015).

As the strength loss increases with the increase in stripping chemicals in the similar trend weight loss percentage of a stripped fabric increases gradually, with the increase in stripping bath, temperature and concentration of stripping chemicals. For example a fabric dyed with 2.5% and 5% shades when stripped off with the same procedure as mentioned above it showed the maximum weight loss percentage of 4.91% and 5.99% respectively.

Pilling strength

To understand the pilling resistance it is very important to have a concept about pilling. Pilling is the formation of clusters of interlinked/knotted fabric, which are located on the surface of fabric by more than one or the only one fiber. So pilling resistance is the resistance of these pills on the surface of fabric (Dockery et al., 2009). In this method pilling resistance of the decolorized fabric was evaluated in SN 198525 procedure using the pilling tester and Martindale Abrasion. Dyed fabric having high level of pilling resistance as compared to striped fabric. Due to the formation of blurred and fuzzy surface of the stripped fabric at high temperature.

Fabric Absorbency

Absorbency of a fabric is the ability of the fabric to absorb the moisture so fabric absorbency increased during the stripping process so that a stripped fabric having more absorbency as compared to dyed one. Due to the formation of alkaline solution, intra-crystalline (swelling agent) is operative in releasing the crystalline zone of cotton fabric in addition to amorphous zone. So that stripping agent may attack this zone. Which liberates the –OH group attached to the cellulosic fabric, to maximum range that formally formed the covalent bond? That's why the stripped fabric has more ability to absorb the water (Fan et al., 1987).

Drawbacks

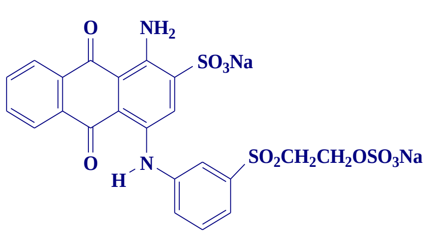
Here are some drawbacks related to reductive stripping and feedback on how we can minimize them. The stripping of cotton fabric dyed with reactive dye directly damages the fabric quality during the process of stripping. In the stripping process it is necessary to consider the fabric quality. As we know that stripping is the process of dye destruction by using the harmful chemicals so that we cannot stop their adverse effect on the fabric quality but we can lessen this harmful effect within a certain range. By decreasing the concentration of alkali reductive stripping chemicals instead of using 10g/L caustic and hydrose, use of 5g/L caustic and hydrose used in industries for the stripping process so with the help of these concentrations we can lessen the loss of fabric quality within 5% using the combination of both stripping chemicals (Uddin et al., 2015).

Oxidative Color Stripping

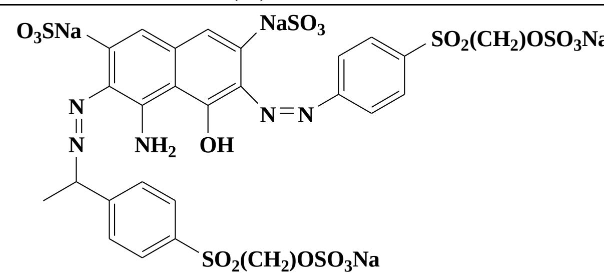
Advanced Oxidation process is the type of chemical stripping in which chemical reaction of the oxidation potential 2.07 V has been used, that produces hydroxyl free radical (OH.) as an operative oxidant with low working parameters (Ronerco et al., 2003; Perincek et al., 2008). It has the potential to degrade the dyes and reduce the contamination present in wastewater. At that time ozone is quickly gaining the attention of the researcher to stripped the textile waste fabrics (Khan et al., 2010; Sevimli and Sarikaya 2002; Rizvi et al., 2013; Somensi et al., 2010), whiten the wood blend (Govers 1995; Gierer 1997; Kishimoto et al., 2003; Ashori et al., 2006), and fabrics such as cotton, jute, angora rabbit and silk (Prabaharan et al., 2000; Prabaharan and Rao 2001; Sargunamani and Selvakumar 2006; Perincek et al., 2007;Perincek et al., 2008; Eren 2011; Arooj et al., 2014; Arooj et al., 2015; He et al., 2018) clearing of polyester blend through reduction (Eren 2007; Eren 2009), and by fixing the unfixed reactive dyes from fabrics in textile sectors (Shaikh et al., 2010 ; Shaikh 2013).

So this process has been recognized for their operational capability to lessen the organic refractory pollutants through contact with hydroxyl radicals, and would be a good color stripping alternative. Here I discuss a few of the literature in which the advanced oxidative process has been used. To evaluate the color stripping process by using ozone, four reactive dyes were used to dye the cotton fabric and then stripping off the cotton stuff dye with (four) reactive dyes (Yigit et al., 2018). In this strategy they optimized the pH, treatment time, ozone-dose, and concentration of dye by mean of the ozone color stripping. Effectiveness of this approach was optimized in terms of the color-properties comprising lightness difference, the lightness and color differences.

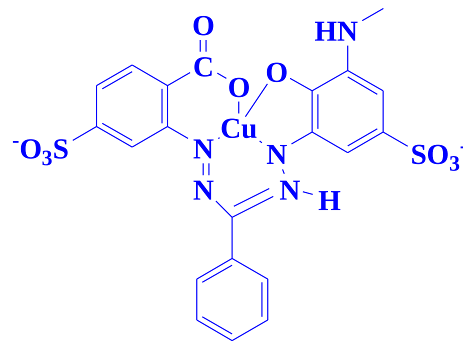
The chemical effluent produced by the ozone process of stripping was lesser than the discharge provided by the traditional stripping process. In her article she showed the chemical structure of 4 reactive dyes named as Reactive blue (19) C.I, Reactive black (5) C.I, Reactive Blue (220) C.I and Reactive yellow (138). As shown down



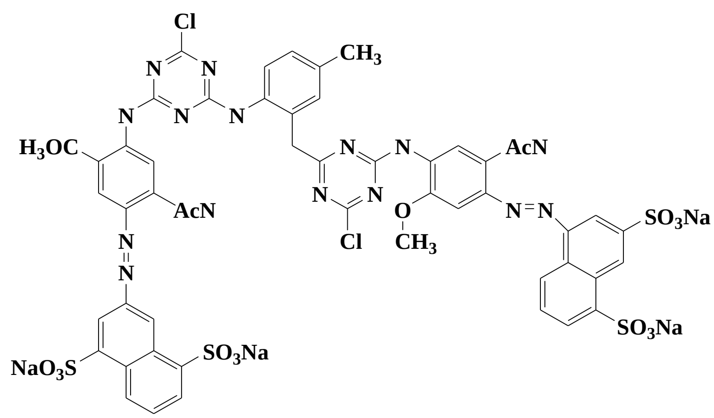
Reactive Blue 19



Reactive black 5



Reactive blue 220



Reactive yellow (138)

Conditions required during ozone process

Optimized condition of the given process was obtained with the variation in pH i.e. 3,5,7,9 and 11 similarly for ozone dose it was 2,4,6,8 and 10 g/h, time 15,30,45,60 and 90 minutes, concentration of dye 0.5%, 1%, 2% and 4% and then optimized the overall result and finds the best one.

Effect of pH and time

After performing an advanced oxidative process their results revealed that effective color stripping of ozone treatment was achieved at 45 min, having 10g/h ozone Dose. It was also investigated that the efficiency of the stripping process depends on the pH and the best results were found at 3-5 pH. It means that ozone was the most stable, choosy and soluble in reaction condition at the lower pH (Bouchard et al., 1995; Siddiqui et al., 1996; Adams 2002; Kishimoto et al., 2003; Ronerco et al., 2003). Optimum pH of this process was 5 for finest stripping. Below this the significance of the treatment became ineffective.

Drawbacks and advantages

The effluents produced as a result of conventional-stripping methods is higher as compared to this method, effluents caused by the ozone process is 97% lessen which proved that ozone stripping process was environmentally friendly because it requires less chemicals and energy (Arooj, Ahmed et al. 2020). The result evolved that Stripping efficiency has been decreased with increase in dye concentration from 0.5% to 4%. Which revealed that decolorization of dyed fabric required longer exposure time and higher concentration requires higher ozone dose. So that the strength of ozone stripped fabrics was lower as compared to conventional methods but within the limited range. After achieving the best result at optimum pH 5.Efficiency of decolorization process became ineffective below this pH means below pH 5, requiring additional acids. Which increases the cost, release of hazards effluents and the quality of the fabric also decline (Arooj et al., 2014; Perincek et al., 2007). The most reliable and interesting approaches that have been developed on the basis of eco-friendly, cost effective and time-consuming strategy employing the UV/TiO2, UV/H2O systems better stripping efficiency and performance has been observed (Long et al., 2017).

Photo-Catalytic Method of stripping

(Long et al., 2017) was the first scientist who has studied a photo-catalytic method of stripping by using a nano TiO2. In principal, this technique was based on the production of strong reactive oxidizing and reducing agents, e.g. Hydroxyl radicals (•OH), superoxide radical oxygen ions (•O2-), per hydroxyl radicals (•OH), hydrogen peroxides (H2O2), photo generated electrons (ecb-) and holes (hvb+) etc., no inclusion or residual high chemical content of UV radiation on a TiO2 or nano-TiO2 semiconductor catalyst (Rauf et al., 2011).

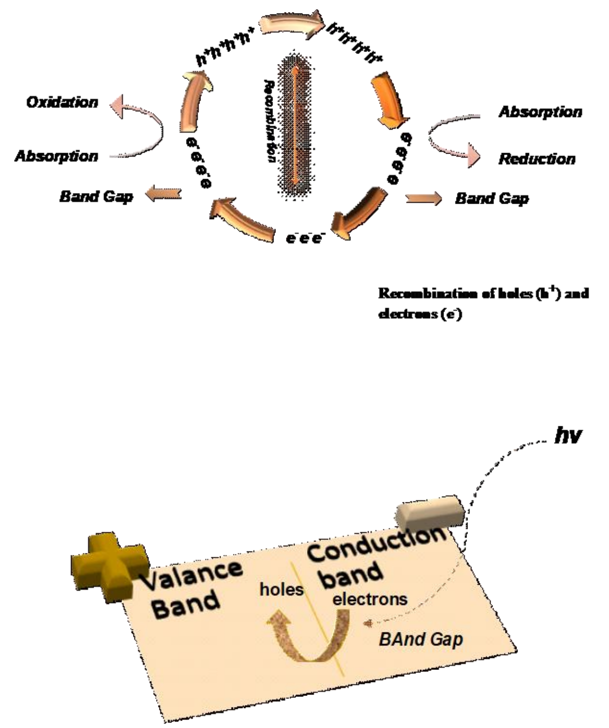


Fig 3: Mechanism of photo-catalytic stripping

Chemical equation for Reduction

$$H_2O/OH^{\bullet} \longrightarrow H^{+} + HO^{\bullet} / HO^{\bullet}$$

Chemical equation for Oxidation

$$O_2 \longrightarrow O_2^{\bullet} / HOO^{\bullet} / H_2O_2$$

These free species stripped the dyed fabric.

The species that has been formed by the photo catalyst oxidation and reduction have sufficient capacity for oxidation and reduction such as they have potential to oxidize the most reactive hydroxylic radicals (•OH) and photo generated holes (hvb+) to 2.27eV. Electronic structures of matter and the substitution of complex aromatic structures in dye molecules were easily attacked and decomposed (Rizvi et al., 2013).

TiO2 Catalysts had significant advantages, such as highly reactivity, efficient nature, photo-catalytic stability, chemical and biological inertness, non-toxicity, low cost and the insoluble in water. Keeping in view, photo-generated species are clean and ecofriendly. While the absorption of color stripping molecules was most commonly found at the inner surface of the compact fiber substrate. The transition, adsorption, diffusion and eventually fixation techniques during the dyeing phase were consistent with conventional fiber coloring theory (Jung et al., 2018). The color stripping conditions due to the use of heterogeneous photo-catalytic technique were therefore very distinct from conventional color decomposition in solutions, since dye molecules were bound to the strong phase of the fiber substrates. Literature has rarely been used to study the color stripping of cloth or other substrate using photo-catalysis, with the exception of a few previous works (Sargunamani and Selvakumar 2006). In this method, UV irradiation incorporated with the reducing agent (sodium hydrosulfite) possesses valuable stripping results with the potential opportunity of the cotton fabric dyed with reactive dye. Tentatively, 253.7 nm main wavelength of irradiative UV light was use having a series of dominant and excited photons with 4.89eV of energy (Fujishima, et al., 2000; Rauf et al., 2011; Hathaisamit et al. 2012). These photons were usually higher than the bond energies of the reactive dyes and sodium hydrosulfite, predominantly bond energy S-S weaker in Na2S2O4 (Jung et al., 2018; Vellanki et al., 2013; Vellanki and Batchelor 2013). Subsequently the irradiated UV photon induce the electron from ground state to excited one or it may decompose the various ions like SO32-, S2-, HSO3-, S2O32- and S2O52- in the reaction medium (Jung et al., 2018; Vellanki et al., 2013; Vellanki and Batchelor 2013). Hence, they readily rupture the compounds; molecule and ions present the system for the generation of the most active and dominate reducing and oxidizing species. Normally, UV photon species was resembling like sulfur dioxide radical, sulfite radical and dithionite radical anion, hydrogen radical, hydroxide radical and hydrated electrons as mentioned below (Vellanki and Batchelor 2013; Vellanki et al., 2013).

$$S_2O_2{}^{-4} \rightarrow \square v\, 2SO^{\cdot -2} - S_2O_4^{-2} \rightarrow \square v S_2^{\cdot} - S_2O_2{}^{-4}$$

$$S_2O_2^{-4} \rightarrow \square v\, S_2O^{\cdot -4} + e^{-aq\cdot} S_2O_4^{-2} \rightarrow \square v S_2O_4^{\cdot} + e^{aq\cdot -}$$

$$SO_2^{-3} \rightarrow \square v\, SO^{\cdot -3} + e^{-}\, aq.SO_3^{-2} \rightarrow \square v SO_3^{\cdot} + e^{aq\cdot -}$$

$$\begin{aligned} &\textit{Active species} + \textit{Cotton fabric}_{dyed} \\ &\quad \xrightarrow[\textit{lower temperature}]{} \textit{Cotton fabric}_{\textit{Colorless fragment of dyed molecules}} \\ &\quad + \textit{Active Species} + \textit{Cotton fabric}_{dyed} \xrightarrow[\textit{lower temperature}]{} \textit{Cotton fabric} \\ &\quad + \textit{Stripped fabric} \end{aligned}$$

Hence, these active species have enough power to attack and rupture the molecule of dyes linked with the surface of the fabric at low temperature as explained in the above equation. Moreover, they also show the capability of diffusion and adsorption at the surface of macro-fiber and they have no need for high temperature for thermal initiation as it required during the conventional method of stripping altogether, the UV irradiation generated photons, effectively promoting the electrons e- from the initial state to the excited state in the dyes molecule attached on the surface of the fabric, thus increased the effect of degradation of the dye during the stripping process.

So, Photo-catalytic stripping of cotton fabric dyed with the fixed reactive Red (X-3B) dye using a photo-reactor, a self-built system of nano-TiO2/UV by dipping manner was studied and then evaluate the effect of pH, tensile strength, ATR/FTIR, and SEM. Here I discuss the effect of pH and temperature.

Effect of pH & Temperature

The initial pH of the working solution having the initial concentration of 50mg/L was conducted in the self-built reactor of nano TiO2/UV at 20oC for 60 minutes. PH value was a range from 2-12 and it showed first it increases, with the highest stripping efficiency i.e. 95% then pH has no significant effect by increasing or decreasing the values. It means when we achieve the best result of stripping at the initial pH range of 2 then there is no need to add any oxidative or reductive agents to enhance the stripping efficiency.

Tensile strength

Tensile strength of the treated fabric revealed that a significant effect of tensile strength was observed as we moved from pH 2 to 8 with the increase in pH strength of fabric. The lowest tensile strength about 36.8 % was observed at a pH of 2 similarly the highest tensile strength was observed at pH 8.00 and it was about 64.3%.

So from the above results, it was observed that significant stripping of the fabric was achieved at the mild conditions, and no need to increase oxidative agent or reductive agent to enhance the stripping percentage. It was clear that the UV/Na2S2O4 system was the most reliable, energy conserver, and effective one for the removal of dyes and unevenness of the fabric. After recycling the decolorized fabric may be recycled by passing it through a series of reactions under different conditions for the utilization of textile effluents.

Recycling of cotton waste fabric

The growth in the textile sector due to rapid fashion culture generates a large amount of attire waste most commonly cotton blended fabric waste. The fabric waste can be used by the regeneration of cotton. Regeneration means the use of waste fabric to form new ones. For this purpose many chemical and physical strategies adopted in which the chemical and physical structure of the waste blended cotton fabric interrupted and generated cotton fabric (Ma et al., 2020). (Shuhua et al., 2020) conduct valuable research on the strategies that were helpful and play a major role in the process of recycling. Up to till, in the process of recycling, the blended cotton waste was a breakthrough chemical process regarding degradation (cellulose polymer degrades into lower organic molecules as polysaccharide degrades into smaller one glucose further degradation converts the glucose molecule into ethane or methane).

The physical process like dissolution that converts cellulose waste fabric into cotton without altering its chemical structure. Different methods and the chemical was used such as ILs, used of NaOH in the presence of urea, NMMO system and various acids/basics for the dissolution of cellulose waste fabric generated in the textile sector or pre-treated the waste fabric into the recycled fabric (Shuhua et al., 2020). Moreover, the usages of these chemicals and systems have many drawbacks. As NMMO was costly and it changes the crystallinity of cellulose fabric. Similar ILs have a high viscosity and are harmful during the biodegradation so that till now it was not applied (Holm and Lassi 2011).

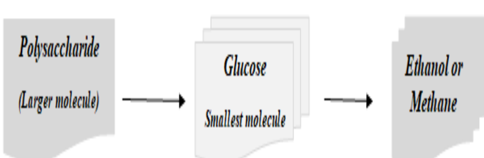


Fig 4: Degradation of cellulose fabric via chemical process

During the acidic and alkali usage in the process of recycling these chemicals have high concentrations and dissolved the crystals of cellulose in the maintained condition at moderate temperature and atmospheric pressure. Furthermore, NaOH was not able to dissolve the cellulose fabric and acids were harmful to the environment as well as damage the nearby region of cellulose during the hydrolysis of the OH group.

To tackle all sorts of issues it was imported to find some technologies with the usage of non-toxic chemicals that were cost-effective and non-corrosive during the pre-treatment process of the cotton waste fabric. At that time, there were few topics in the literature that tackle these issues. (Uchimaru et al., 2013) work on the project coloring the recycled fabric in which he studies the dyeing and coloring problem regarding the textile sector during the process of recycled fabric. By preparing the dyes and group of dyes with the hues and then applying these colors to the recycled fabric. After their appliance, the dyed, recycled fabric was subjected to the analysis for the detection of colorimetric data through a spectrophotometer. In this analysis, they observed the: a*, b*, L* and difference in light. Also, the color intensity was investigated in this analysis and compared the resultant data of dyed fabric which was recycled with the waste dye fabric. The valid combination of hues was separated and subject toward the sensory colorimetric assessment. The application and effects of dyeing were not studied. This study also revealed that during the process of regeneration a lot of side product also generate that was an expensive way to refine the desired product, as well as the method, was time-consuming

The systematic diagram showed the pre-treatment process for the recycling of waste cotton fabric. After the pre-treatment process which was carried out in the presence of phosphoric acid recycled fabric was obtained further procedures in which regenerated fabric was obtained may be crude polyester, may be regenerated cellulose fabric which was present in the suspension.

It was crude polyester then it moved towards the washing and polyester was obtained. During the washing process, it may go towards the regenerated cellulose fabric as a suspension. This suspension was filtered to form the regenerated cellulose material which was further hydrolyzed and yield the glucose molecule.

Follow sheet for regeneration of fabric

The whole process of the regeneration of cellulose fabric is shown below for a better understanding.

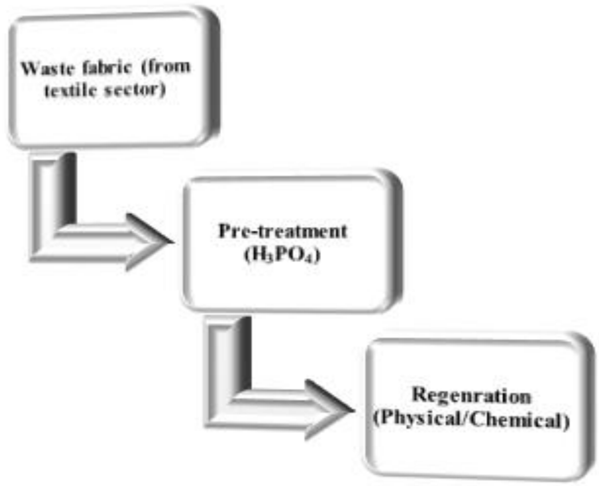


Fig 5: Regeneration of cellulose fabric

Regeneration of waste fabric passes through different physical and chemical processes and forms the polyester from the crude polyester which was listed below.

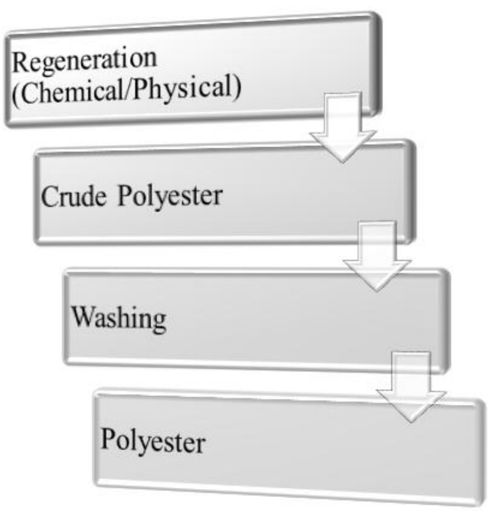


Fig 6: Regeneration of polyester

Same process of regeneration was listed below for the formation of glucose from the waste fabric.

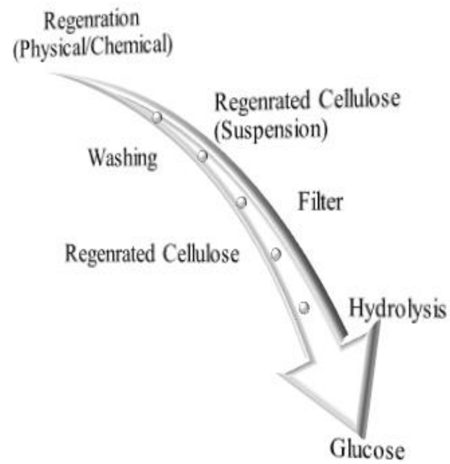


Fig 7: Regeneration of cellulose to glucose

Conclusion

Chemical stripping is the best procedure to remove the unevenness and dyeing faults which improves the dyeing liabilities, the appearance of the fabric after stripping and a new look can be given to the fabric through the recycling and re-dyeing process. In bulk production, the stripping process may be partial or complete which depends on the dyeing faults under consideration and shade which is expected to achieve. Furthermore, the stripping process can be carried out through different methods but here we have discussed three methods i.e., reductive, oxidative, and photo-catalytic stripping method. In the reductive color stripping manner, a lot of harsh chemicals, high concentrations of operative chemicals, and working parameters are being practiced for the elimination of the faulty dye which is not feasible both economically and environmentally. And also this treatment has adverse effects on human beings so we move towards some better choices such as the oxidative one. The oxidative color stripping involves an optimized ozone stripping process that is an environment-friendly alternative as compared to the conventional chemical stripping processes as it saves water, energy, chemicals, and wastewater treatment expenses. But in this technique, after reaching the optimum condition it required more concentration of chemicals, time and temperature to give better stripping results. So, this technique is limited to a given extent due to the increase in the concentration of dye and stripping chemicals which make this practice comparatively costly and it may also cause environmental pollution but still this technique is considered to be more effective than the reductive one as it is less harmful towards humans. A novel, energy-conserving and ecofriendly method for stripping of reactive-dyed cotton substrate was successfully developed by the means of an in situ photo-generation of active and powerful species at atmospheric temperature in a dipping manner such that in a UV/Na2S2O4 system. The achieved results make known that the proposed stripping method and system is very efficient for the decomposing of the reactive dye molecules fixed on the cotton substrate by a photo-catalytic initiation in the UV/Na2S2O4 system which go with the high tensile strength retention by the stripped substrate. It is obvious that the developed color stripping method and the UV/Na2S2O4 system are feasible, applicable and very efficient for color stripping of conventional reactive dyes on cotton substrates with a green, energy-conserving and ecofriendly characteristic in the textile industry. So at the end, we may conclude that the photo-catalytic color stripping technique is paramount among the all said techniques and the oxidative stripping is also comparatively better than the reductive stripping. After stripping the astonishing look is given to the stripped fabric through recycling.

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