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Research on reuse of standing dye bath of reactive dye

Ashraful Alam [1], Zakaria Ahmed [1,*], Neaz Morshed [2], Pulak Talukder [1] and Taslima Rahman [3]

[1] *Mechanical Processing Division, Bangladesh Jute Research Institute, Dhaka-1207, Bangladesh.*
[2] *Department of Yarn and Fabrics Production, Bangladesh Jute Research Institute, Dhaka-1207, Bangladesh.*
[3] *Department of Microbiology, Bangladesh Jute Research Institute, Dhaka-1207, Bangladesh.*

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Abstract

The aim of the work was to find out suitable method of dyeing so that costly reactive dye bath can be reused without draining them. Because of the hydrolysis of residual reactive dyes due to the fixation conditions and because of relatively large amounts of dyes and salts left in the effluent, reusing hydrolyzed reactive dyes is a challenge to dyers. Two reactive dyes were examined (reactive red, reactive yellow and two fabrics: nylon, silk as well as silk fiber and nylon yarn). When using suitable dyeing conditions by controlling pH and temperature, hydrolyzed reactive dye baths for silk and nylon dyeing showed very good wash and moderate colorfastness.

Keywords: Reactive dye; Yarn; Resuse; Bath

1 Introduction

A major environmental problem of textile effluent is from the dyeing waste water, Colorants, heavy metals, and high concentrations of salts are all water pollutants [1]. The textile industry consumes large volumes of water and in turn produces substantial quantities of polluted effluents. Approximately 40% of reactive dyes used during the textile processing remain unfixed on fibers and are responsible for the coloration in effluents. Various conventional methods are being used to treat textile effluent. To decrease the concentration of these chemicals in the effluent discharged, the major effort is on the removal of toxic materials from the effluent. Another approach, dye bath reuse has more and more attention in recent years. Dye bath reuse not only reduces the amount of toxicity of dyeing effluent but also saves the expenses the dyes, chemicals and energy considerably [2-4] though a dye bath is a complex system with many variables not easily controlled exactly the same for reuse, excellent batch-to batch shade uniformity could be achieved. Reactive dyes are one of the most commonly used dyes because of their excellent wash-fastness and convenience in application. The affinity of reactive dyes to cellulose is not very high. Therefore, lots of salt (e.g. 50-1 00 g/l) is, used to improve dye sorption. However, the fixation of reactive dyes is not high, with a yield of 50-90%. In other words, up to 50% of the dyes are left in the bath after dyeing. Both high concentrations of salt and dyes left in the bath cause pollution. It was reported that the multi shade reuse was also feasible in addition to single shade reuse, but the buildup of finishes and other extractable impurities from the fiber may limit the reusing cycles due to the possible interference of these chemicals with dyes and other dye bath additives [5-6]. As a matter of fact, the reactive dyes pose the main problem in color cleanup. It is not an exaggeration to state that without solving the problems of reactive dye bath reuse, dye bath reuse technology is incomplete, which was the mani focus in present research.

*Corresponding author: Zakaria Ahmed; Email: zakariaahmed70@gmail.com
Mechanical Processing Division, Bangladesh Jute Research Institute, Dhaka-1207, Bangladesh.

2 Material and methods

All the chemicals (Sodium Chloride, Sodium bi carbonate, Wetting Agent and Sequestering Agent) used in this project work were reagent grad. The present experiment was done where the cotton was dyed with fabric with a reactive dye brand. For reaching the target goal experiment was normally carried the full bath reusing technique where tested mainly four parameters of two instinct materials these were mainly for protein fiber (silk) and Nylon which were mainly in the form of Silk yarn, Silk fabric, Nylon yarn and Nylon fabric (Fig 1). The two brand dyes and two different types of reactive dye of swiss colors (Reactive Red and Reactive Yellow) were used for the dyeing purpose in present experiment (Fig 2). As the target of the present research was to completely reusing the left dye bath liquor without adding any extra chemical just by keeping the pH in the acidic medium (<7) which was in the alkaline medium (>7) and thus, hydrolysis was done at the begining . By using the Reactive Dye (1% owf), Sodium chloride (15g/l), Sodium bi-carbonate (5 g/l), Wetting agent (0.5 g/l), Sequestering agent (0.5 g//l), M:L ratio (1:20) at 90^{o}C for 40-60 mins and the reactive dye bath where 10-50% reactive dye left on it.

Silk fabric | Silk yarn | Nylon fabric | Nylon yarn

Figure 1 Protein fiber (silk) and Nylon

Reactive Red | Reactive Yellow

Figure 2 Different types of reactive dye of swiss colors

After completing the dyeing procedure the fabric from the left solution of dyeing system was removed and added the water on it if there was too short liquor than the expected level where the pH of the standing dye bath of reactive dyeing system was checked by pH meter. The pH was initially in the alkaline medium (Level of 9-10), but according to the above description and dyeing condition, the pH of the dye bath was adjusted to near about 4.5-5. Then the re-dyeing procedure was started by using just final dye bath that was not actually. Completed the task was washed out the unfix dye that could attach with the surface of the treated material without any bond or attraction. So lower the unfix dye on the surface of the treated material higher its wash fastness. To check the wash fastness of the re-dyed material that dyed by the hydrolyzed reactive dye bath, the soaping process for every target sample was carried out with Standard soap (5 g/l) and Sodium bi-carbonate (2 g/l) recipe of M:L Ratio (1:50) at 60^{o}C for 30 min. After finishing the above process cold wash was done and then wash fastness was rated by attaching the multi fabric with the hydrolyzed dyed materials and fastness is checked by comparing with fastness scale. By applying this process, normally the moderate wash fastness

was achieved in case of every tested material. Some of the dyed materials was superb hydrolyzed fixation rate that would be helpful not to draining the left dye bath for the environmental issues as well as economic state.

3 Results and discussion

3.1 In case of silk and nylon yarn

Firstly tested the silk yarn. Silk is normally protein fiber that has the attraction to the hydrolyzed reactive dye bath as like acid dye. So first target was to apply the above process on silk yarn and for that purpose, the dye bath of cotton fabric was prepared and it was carried as like the normal dyeing of cotton to get the hydrolyzed reactive dye bath. As normal dyeing procedure was over then the hydrolyzed reactive dye bath; therefore, it is must to control the pH for using this bath for the further use to dye the project material. By gradually addition of the acetic acid, the pH in acidic medium acid as the primary pH of the dye bath was in alkaline condition; then the dyeing by hydrolyzed reactive dye bath was carried and after that soaping was also done (Fig. 3).

Dyed silk yarn by the hydrolyzed Reactive Dye

Dyed cotton by Reactive dye

Hydrolyzed dyed silk yarn after soaping

Normal cotton dyed fabric

Hydrolyzed reactive dyed nylon yarn

Hydrolyzed reactive dyed nylon yarn after soaping

Figure 3 Treated and untreated dye sample of silk and nylon yarn

3.2 Wash fastness of Nylon Yarn and Silk Yarn

The reactive dye bath using cycle for nylon and Silk yarn, where the wash fastness of nylon and silk yarn after soaping is poor to moderate by applying the same process and procedure as well as recipe (Table 1).

Table 1 Wash fastness of Nylon Yarn and Silk Yarn

Wash Fastness Test	Nylon yarn	Silk Yarn
For 1st time dyeing	2-3	2-3
For 2ndtime dyeing	3	2-3
For 3rdtime dyeing	2-3	2-3
For 4thtime dyeing	3	3
For 5thtime dyeing	2-3	2-3

3.3 In case of silk and nylon fabric

The silk fabric had a moderate wash fastness which was tested by attaching the multi fabric on it by applying the same process and procedure (Fig. 4).

Normal dyed cotton

Dyed silk fabric by using left dye bath

Normal reactive dyed cotton

Hydrolyzed dyed Nylon

Figure 4 Treated and untreated dye sample of silk and nylon fibrics

3.4 Wash fastness of Nylon and Silk fabric

Same process and procedure as well as recipe was applied for wash fastness of nylon for analyzing the samples. The nylon and silk fabric had much more good wash fatness than all of those and also have the good substantively toward the hydrolyzed reactive dye bath (Figure 5).

Hydrolyzed reactive dyed fabric after washing

Hydrolyzed dyed silk fabric after soaping

Wash Fastness Test	Nylon Fabric	Silk Fabric
For 1st time dyeing	3	2-3
For 2ndtime dyeing	3	2-3
For 3rdtime dyeing	2-3	2-3
For 4thtime dyeing	3	2-3
For 5thtime dyeing	2-3	3

Figure 5 Wash fastness of Nylon and Silk fabric

This project can be using for the hydrolyzed dye bath for those materials which has some fixation and attraction toward hydrolyzed reactive dye. The silk and nylon in their yarn and fabric form and dyed them by two brand reactive dye that is reactive red and reactive yellow of Swiss color. In case of our test was done and would not get the satisfactory result with the final product. Here firstly dyed the silk materials with the hydrolyzed reactive dye bath .but it was not so good and the wash fastness properties also poor to moderate. But in case of nylon we got the better result than the silk materials. Hydrolyzed reactive dyed nylon materials was much better wash fastness than the silk materials that is near about to moderate. The main problem of this dyeing procedure is not to find the required dye shade that we want. Therefore, this process only for light shade and for local product as it is very hard to get the shade as like the fresh reactive dyeing .In additioncan topping the hydrolyzed dyed materials to get the exact shade although it requires further fresh dye which could reuse again. In recent years it is very concerning that the effluent that is left from the dye bath highly hazardous for environment, especially for water and human health. So more technology and work should be employed on this topic for finding a perfect reusing technology of reactive dyeing process as the reactive dye is the most widely used in Bangladesh as well as around the whole world for its better wash fastness, availability and cheap rate of cost?

4 Conclusion

Reactive dyes are the most widely used because of their excellent wash fastness and convenience in application. The affinity to cellulose fiber of reactive dye is not too high. So, a large amount of residual hydrolyzed dye left in the dye bath that leave on the effluent subsequently. Reusing of this left bath is more concerning matter for environmental and cost reduction. Direct reuse of reactive dye bath is possible. Acid dye able textiles such as nylon and as well as protein fiber had very good exhaustion of hydrolyzed reactive dyes from the dye bath after cotton reactive dyeing process. Nylon and silk were dyed by using the left dye bath of cotton reactive dyeing that has moderate to good wash fastness. Here the nylon gives more good result than the silk materials. The suitable batch dyeing conditions were 90 degree Celsius or higher, for one hour at pH 4.5-5. Electrolytes left after initial cotton dyeing decreased dye sorption. The sensitivity of salt to dye sorption dependent on fiber structure and dye properties. The effect of salt on dyeing nylon was more than that the silk. Adjusting the liquor ratio could decrease the salt effect and modify shade depth of the goods. After such reuse if the dye left was negligible, the bath could be reused for cotton dyeing to save salt and water. Although reuse of hydrolyzed reactive dyes is not as convenient as using acid dyes directly, especially when conventional reactive dyeing and acid dyeing are not in the same plant, is study shows the possibility of complete reuse of a reactive dye bath. To solve the transportation problem, hydrolyzed reactive dyes could be concentrated first through adsorption, filtration and other methods. At such time these concentrated dyes could be sent to acid dyeing facilities for reuse. The colorless dye bath left after such concentration could be reused for successive reactive dyeing.

Compliance with ethical standards

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Disclosure of conflict of interest

All authors declare that they have no competing interests.

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