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Effect Of Chitosan On Cotton For Dyeing With Reactive Dyes

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Abstract:
Treatment of cotton with chitosan has gained popularity as the treatment has improved the physical and chemical characteristics of the fabric. However, different application methods were employed for pre treatment of cotton with chitosan. Hence a study was undertaken to study the impact of chitosan on cotton as a surface modifying agent with reference to dye ability of fabric. Treatment with chitosan was performed in three methods; on weight of fabric weight by volume and volume by volume concentration and the treatment methods were evaluated based on the acquired stiffness and colour strength dyed with reactive dye.

Keywords: Cotton, chitosan, treatment methods, on weight of fabric, weight by volume, volume by volume concentration, dyeing, stiffness, colour strength

1. Introduction:

In search of implementation of sustainable technologies and environmentally safer methods for processing in the textile industry, chemical treatments using biodegradable polymers or biopolymers has gained momentum in recent years. Biopolymers are extensively used in the textile industry for various purposes. Among the biopolymers used, chitin or chitosan which is considered as an animal based biopolymer is being used in various applications in the textile industry(Morin-Criniet al., 2019).

Chitin is a naturally occurring polysaccharide with a similar structure as cellulose. Chitin has diverse applications when converted to chitosan. The features of chitosan such as non-toxicity, biodegradability, antibacterial activity and polycationic nature made it suitable for textile applications (Komi and Hamblin, 2016).

Cotton being a natural cellulosic fibre has receptivity to various dyes. However, conventional process of dyeing involves usage of dyes, chemicals and auxiliaries which assists in exhaustion of dye, development of colour and fixation of dyestuff onto the textile substrate. Improper dyeing may yieldto release of colour, chemicals and other auxiliaries in the dye effluent which may lead to other environmental hazards.In controlling the use of chemicals in the textile wastewater after dyeing, many researchers have studied earlier to modify the fibre chemically by introducing cationic sites in cotton.

Various chemicals are employed for cationisationon cotton, among which chitosan has been widely researched in recent years (Ashenafi, 2020). Chitosan treatment modifies the cellulose molecule and makes it strongly cationic thus increasing the affinity between cotton and dye thus further assists in reducing the consumption of chemical, water and energy (Correia et. al., 2020). A number of studies published, explaining different methods of application of chitosan for pre treatment. For this reason, the present study was carried out for optimisation of chitosan treatment for dyeing of cotton based on the quantity of chitosan.

2. Experimental:

2.1 Selection of materials:

2.1.1 Fabric: Bleached and mercerised plain woven cotton fabric was selected for pretreatment with fabric count of 98 x 76 per inch; thickness of 0.21 mm and 80.5 g/m^2 GSM.

2.1.2 Chemicals: Chitosan extracted from shrimp shells (75% deacetylated) was purchased from M/S Lobachemie Pvt. Ltd, Mumbai. Chemicals utilised for pre treatment and dyeing are of laboratory grade.

2.1.3 Dyes: Dyeing of fabric was carried out by using Commercial Reactive dye (Remazol Brilliant Blue R).

2.2 Sample preparation:

Cotton fabric was pretreated with chitosan by three methods such as on weight of fabric (method I), weight by volume (method II) and volume by volume (method III) concentrations by exhaust method. Four different concentrations 0.5, 1.0, 1.5 and 2.0% were employed for pre treatment. Chitosan solution was prepared by dissolving required amount of chitosan powder in 2% (v/v) acetic acid at room temperature. The fabric was treated in the solutions for 60 min at 60°C temperature. Excess solution was squeezed and was utilised for dyeing.

2.3 Dyeing parameters:

The treated fabrics were dyed in 2 per cent reactive dye through exhaust method of dyeing following optimum dyeing conditions.

2.4 Evaluation parameters:

Optimisation of chitosan treatment was analysed and evaluated based on acquired stiffness and colour strength values (K/S) of dyed fabrics after five washes.

2.4.1 Stiffness:
Difference in stiffness properties of treated and untreated fabrics in both warp and weft direction were determined by Shirley Stiffness tester following test method IS 6490-1971.

2.4.2 Colour strength of dyed fabrics:
Treated and untreated dyed fabrics were analysed for K/S values by Premier Colour Scan SS 5100A. The colour spectrophotometer was calibrated with the standard white tile before analysing the dyed fabrics for colour strength. Strength of colour was determined in reflectance values at maximum wavelength of absorbency.

3. Results and discussion:

3.1 Treatment with chitosan:
Dissolution of chitosan in acetic acid solution has resulted in viscous solutions. The viscosity was different for all the three methods which were based on the quantity measured for the treatment. The quantity of chitosan weighed for method II was more followed by method I andIII. Therefore the resultant viscosity was more in method IIand succeeded by method I and III respectively. Observations were similar with the study carried out by Jaepyoung et al., (2006). Chitosan has exhibited viscoelastic behaviour by formation of hydrogel in the acidic solution (Chattopadhyay and Inamdar, 2010). The level of viscosity nature exhibited in three methods has resulted in altered stiffness in the treated fabrics.

3.2 Determination of stiffness:
Bending length in warp and weft directions were measured for determination of fabric stiffness. The details of stiffness of the treated fabrics were represented in figure 1. Increase in concentration of chitosan has improved the stiffness of the fabric gradually in all the treatment methods. Difference in stiffness both in warp and weft directions were found to be more in fabrics treated in method IIand lower in method III. The acquired viscosity of chitosan solutions has affected the degree of penetration into the fabric (Chattopadhyay and Inamdar, 2010). The film formed on the fabric surface by the chitosan solution after treatment has contributed to the characteristic stiffness of the treated fabrics (Bhuiyan et al., 2017).

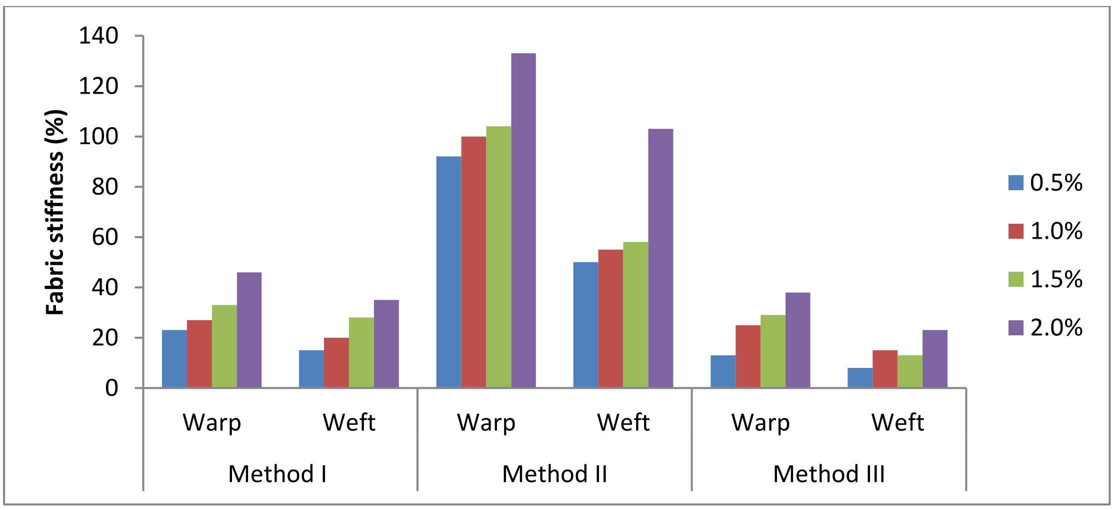

Figure: 1 Stiffness of cotton fabric after chitosan treatment

3.3 Evaluation of dyed chitosan treated fabrics:

Chitosan treated fabrics were dyed in blue reactive dye at optimum conditions. Further, stiffness and colour strength of the fabric were analysed after five washing cycles.

Decrease in stiffness was observed after five washing cycles in all the chitosan treated and dyed fabrics. Method II has yielded higher per cent decrease in stiffness in comparison to other two methods. The applied chitosan was not completely absorbed by the fabric during treatment and instead formed a film on the surface of fabric which was removed gradually during washing. Fabrics treated in method III has exhibited lower difference in stiffness after washes because the treatment was carried out in low viscous solutions which made the chitosan to get absorbed into the fibre.

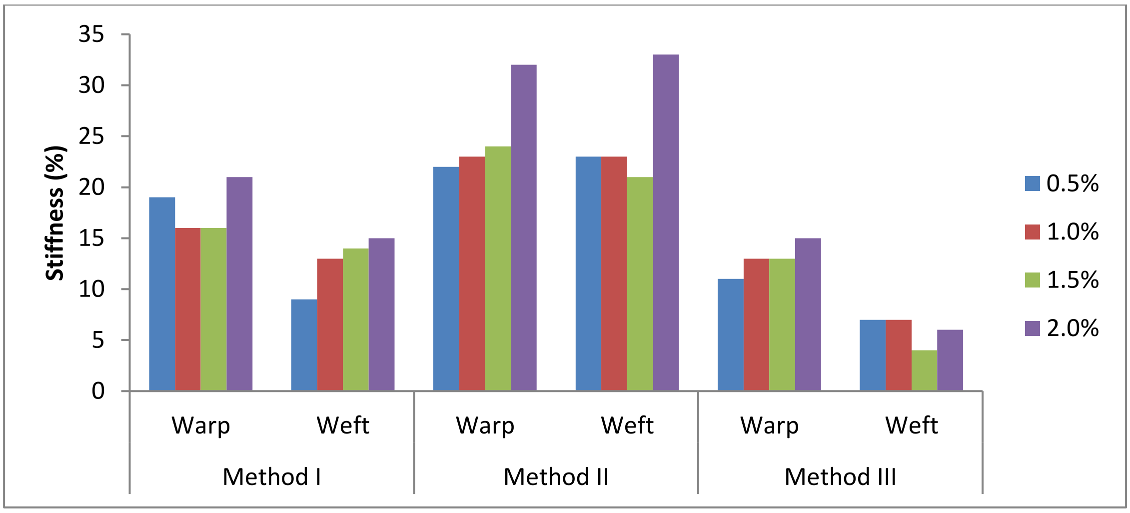

Figure: 2 Stiffness in Reactive dyed cotton after five washes

Analysis of colour strength of the chitosan treated and dyed in reactive dye was carried out after five washing cycles. As evident from figure 3, the per cent decrease in colour strength was observed to be more in control fabric after fifth wash. Among the three treatment methods, higher per cent decrease was observed in method II and lower in method III. Decline in colour strength in method II was more because of the formation of film on the fabric surface which has resulted in lack of spaces and functional groups for the dye molecules to get attached to the fabric (Chatha et al., 2016). The per cent difference in colour strength was minimum in method III among four concentrations of chitosan and was also found that the dyed fabrics exhibited maximum colour strength after wash than the control fabric.

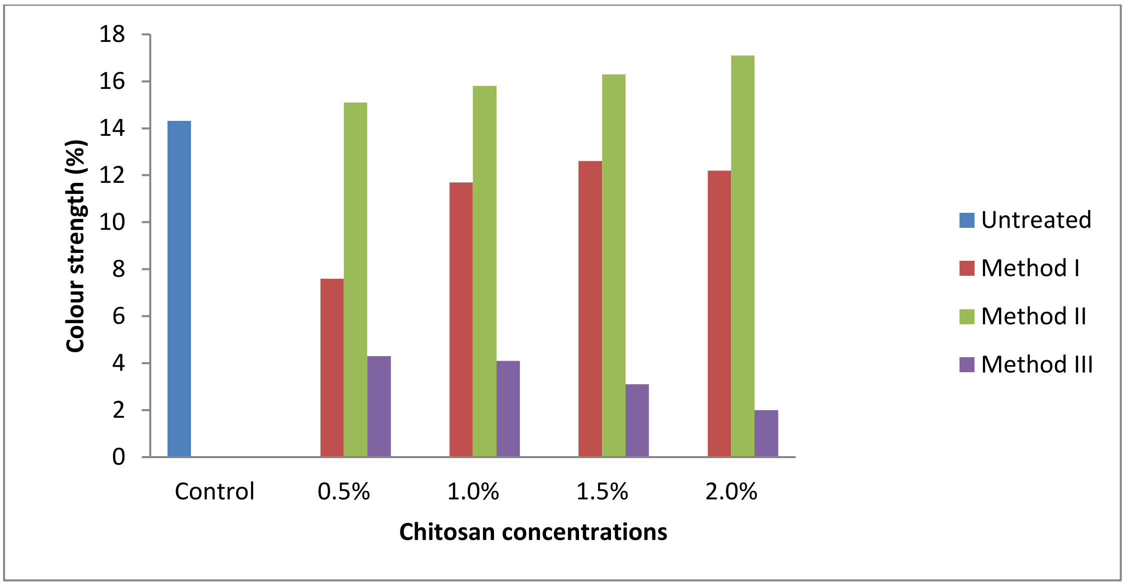

Figure: 3Colour strength of Reactive dyed cotton after five washes

4. Conclusion:

The present study is intended to find out the effect of pre treament suitable for cotton to dye with reactive dyes based on fabric stiffness and colour strength after five washes. Pre treatment of cotton with chitosan was carried out by applying chitosan in three different methods. All the three methods exhibited different levels of viscosity when dissolved in acidic solutions. Among the methods, method II has exhibited more viscous solution which has produced a fabric with higher stiffness and minimum in method III with low stiffness in contrast to other two methods. Accordingly the colour strength was maximum in method II followed by method I and method III. However, after five washes, higher per cent difference in stiffness and colour strength was observed in method II, method I and method III respectively. The per cent loss has higher in method II was due to the formation of film on fabric surface by higher viscous solutions. The lower viscous solution among the three methods that was produced by method III i.e., volume by volume concentration has exhibited increase in colour strength than untreated fabrics and per cent colour loss was also observed to be minimum after five washes. Moreover, in terms of cost of dyeing, volume by volume treatment method was found to be less expensive than the other two methods which could reduce the production cost.

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