STUDIES IN SINGLE-STAGE PREPARATORY PROCESSES FOR COTTON FABRICS

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DOCTOR OF PHILOSOPHY

by

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DEDICATED
TO MY
BELOVED MOTHER
N. VISALAKSHI

CERTIFICATE

This is to certify that the thesis entitled "STUDIES IN SINGLE-STAGE PREPARATORY PROCESSES FOR COTTON FABRICS", being submitted by Mr. N. SUKUMAR, to the Indian Institute of Technology, Delhi, for the award of the degree of DOCTOR OF PHILOSOPHY in the Department of Textile Technology, is a record of bonafide research work carried out by him. Mr. N. Sukumar has worked with my guidance and supervision and has fulfilled all the requirements for the submission of the thesis.

The results contained in this thesis have not been submitted, in part or in full, to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

Fabric preparation has been considered as the back-bone of the chemical processing of cotton textiles. Elaborate procedures have been evolved to ensure perfect fabric preparation, with the result this has become the most time consuming, energy-intensive and laborious step in the chemical processing of cotton fabrics. However, with the mounting energy crisis, during last five years many investigations have been directed to either shorten the fabric preparation sequence or to make it less energy intensive. A single-stage preparatory (SSP) process involving the use of emulsified solvent as the scouring agent and hydrogen peroxide as the bleaching cum desizing agent has been standardised by the author. This thesis is an extension of the previous study and is concerned with the further optimisation of the process as well as with the mechanism of decomposition of hydrogen peroxide. The system has also been investigated with respect to its suitability for low-temperature fabric preparation using hydrogen peroxide as well as sodium hypochlorite.

A critical examination of the above mentioned single-stage preparatory (SSP) process indicated that the pH of the fabric lowered from 10.5 to near neutral during the treatment and a substantial quantity of hydrogen peroxide remained undecomposed on the fabric. In order to further optimise the process and to fully utilise the hydrogen peroxide on the padded fabric, a study was undertaken to investigate

the effect of pH buffers on the SSP process as well as on the decomposition of hydrogen peroxide on the fabric. Two kinds of cotton fabric, one containing acrylic size (Cambric 1) and the other containing starch size (Cambric 2) were subjected to the SSP process with the buffered and unbuffered solution. From the results of these measurements it has been observed that the SSP process is accelerated by the pH buffers, with the result the process can be completed in a shorter time period. Alternatively, one can reduce the quantity of hydrogen peroxide from 1-2% to 0.5-1% and achieve the similar properties of the prepared fabric.

Since it is not known how the decomposition of hydrogen peroxide in the SSP process proceeds, an investigation was undertaken to follow the pattern of decomposition of hydrogen peroxide. The decomposition of hydrogen peroxide is found to follow pseudo- first order reaction kinetics. It has also been observed that the hydrogen peroxide decomposes at a faster rate from the buffered solutions. Furthermore, the acrylic size of the Cambric 1 seems to stabilize hydrogen peroxide. However, the damage to cellulose is more in Cambric 1 than in Cambric 2 fabric.

Since the SSP process is a solvent-assisted scouring process, it was surmised that it should be effective in removing wax from grey cotton at low-temperature. Moreover, since hydrogen peroxide

is capable of bleaching at a low-temperature, an attempt was made to develop a low-temperature SSP process. Of the five different compounds investigated for their suitability to activate/stabilise the hydrogen peroxide in low-temperature SSP process, only trisodium phosphate and tetrasodium pyrophosphate were found to be suitable, and a recipe for the low-temperature SSP process has been suggested. From a study of the mechanism for the activation/stabilisation of peroxide with sodium silicate, it is concluded that the stabilisation of peroxide is by the precipitated silica gel and not by sodium silicate.

Having established that a low-temperature SSP process was feasible, attention was given to the sodium hypochlorite bleaching. An investigation was undertaken to optimise the process conditions for a SSP process utilising sodium hypochlorite as desizing cum bleaching agent. A miniature cistern was fabricated and used. A second-order response surface design of five levels, four variables and utilising 31 different conditions, was chosen to ascertain the optimum process conditions and to evaluate the effect of various bleaching conditions on the properties of the bleached fabrics. A comparison of the properties of the fabric samples bleached with the SSP process with that of the properties of the fabric prepared by the conventional hypochlorite process has been made and the economically practicable optimum process conditions have been reported.

In order to ascertain the mode of decomposition of sodium hypochlorite in the SSP bleach baths, an investigation on kinetics of decomposition of sodium hypochlorite was carried out. From the results of this study, it is found that the hypochlorite decomposition follows as second order reaction kinetics. The extent of decomposition of sodium hypochlorite in SSP process is higher at pH 9 as compared to pH 10 and 11, both in the presence and absence of cotton. The rate constant values are high when cotton is present in the bleach bath. The copper number and carboxyl content of the bleached samples increase with decrease in pH of the bleach bath.

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