STUDIES IN SODIUM CHLORITE BLEACHING

by

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dedicated to my
supervisor

CERTIFICATE

Certified that the dissertation entitled "STUDIES IN SODIUM CHLORITE BLEACHING", which is being submitted to the Indian Institute of Technology, Delhi, by R. Venkatraj, in fulfilment for the award of the Degree of DOCTOR OF PHILOSOPHY is a record of the student's own work carried out by him under my supervision and guidance. The matter embodied in this dissertation has not been submitted for the award of any degree or Diploma.

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ABSTRACT

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Sodium chlorite was introduced by Mathieson Alkali Works of U.S.A in 1939 as a safe bleaching agent for cotton and linen fabrics. Its use subsequently spread to France, Germany, the U.K. and other Europian countries. Though, expensive, than the more established bleaching agents (for instance sodium hypochlorite and hydrogen peroxide), sodium chlorite was preferred for shorter and safer bleaching operation. In some instances, it was possible to bleach unscoured cotton, since bleaching with sodium chlorite obviated the need for kier boiling operation.

The use of sodium chlorite raised problems of corrosion of equipment and evolution of undesirable chlorine dioxide gas. In order to overcome these problems, use of special quality stainless steel, containing molybdenum was recommended along with corrosion inhibiting chemicals and auxiliaries. However, strict pollution control regulation resulted in the ouster of sodium chlorite as general purpose textile bleaching agent.

Subsequently, introduction of synthetic fibres gave an impetus to the use of sodium chlorite, since it is the only bleaching agent which is able to effectively bleach these fibres.

In most of the bleaching processes, acidified sodium chlorite is used at high temperature. This results in excessive evolution of chlorine dioxide. A search is on for an activator which could decompose sodium chlorite at a lower temperature and thereby overcome the problem of chlorine dioxide evolution. Scores of chemicals have been patented which are claimed to activate sodium chlorite at low temperature. Some of them are :

formaldehyde, chloral hydrate, organic esters, acid liberating salts, sodium dichloroisocyanurate etc.

In the present study, two compounds namely triethanolamine hydrochloride (TEA.HCl) and sodium dichloroisocyanurate have been evaluated for their effectiveness as low temperature activators for sodium chlorite bleaching. Furthermore, in order to work out a cost effective process, the scouring and the bleaching steps have been combined.

The first part of the work (Part 3 of the thesis) has been framed to study the possibility of combining scouring and bleaching of desized cotton fabric at low temperature by using an emulsifiable solvent formulation as scouring agent and TEA.HCl activated sodium chlorite as bleaching agent.

For this study, enzymatically desized cambric cotton fabric has been used. The process variables namely scouring agent concentration, sodium chlorite concentration, activator concentration,treatment temperatute and treatment time have been varied at 5 levels. The response surface methodology has been applied to correlate the effect of variables upon the properties of the scoured/bleached fabric. Three important properties namely whiteness index, wetting time and per centage loss in strength have been measured. The process variables have been optimised using canonical analysis. The necessary computer program developed for the analysis was run on an ICL 2960 mainframe computer. The optimum treatment conditions from the statistical analysis worked out to be : Scouring agent 4.5%, sodium chlorite 1.4%, activator 0.6%, treatment temperature 60°C and treatment time 330 to 390 min.

The kinetics of decomposition of triethanolamine hydrochloride catalysed sodium chlorite on a cotton fabric has been investigated at 50°C for various concentration of triethanolamine hydrochloride ranging from 0.25 to 1.00%. From this study it has been observed that the decomposition of sodium chlorite follows a first order kinetics for 0.25% and 0.50% triethanolamine hydrochloride concentrations. The kinetics of decomposition of sodium chlorite in presence of triethanolamine hydrochloride in aqueous medium at various temperature and pH has also been investigated. The decomposition products of the reaction have been analysed for the presence of aldehyde and carboxylic groups. It has been observed that the by-product contains only aldehyde groups. The extent of aldehyde group formation increased with increase in concentration of activator. From these observations, it is proposed that, in order to effectively utilise sodium chlorite for bleaching, the activator concentration should be kept below 0.5% owf.

In spite of its being fibre-gentle, sodium chlorite works out to be expensive and hence it is not generally used for bleaching 100% cotton fabric. However, it is the most satisfactory bleaching agent for polyester. The scouring/bleaching process, optimised in the first part has been subsequently tried on a desized polyester/cotton (67/33) blended fabric in the second part of the study (Part 4 of the thesis). The study has been conducted on similar lines using a three variable and five level response design. The process variables namely, bleaching agent concentration, temperature and treatment time have been optimised by canoniocal analyis.

The optimised recipe has been worked out, taking the whiteness index, wetting time and percentage strength loss of conventionally prepared fabric as standard. The results obtained with the optimised recipe are almost identical to those, achievable in a commercial preparatory process. The optimum treatment conditions for the above mentioned fabric are: scouring agent concentration 2% owf, bleaching agent concentration 0.8% owf, activator concentration 0.4% owf, time of treatment 7-8 h, treatment temperature 55°C.

As stated earlier, various organic compounds have been patented which can activate sodium chlorite at low temperatures. These compounds either get oxidised into acids or liberate acids on hydrolysis. One such compound which has been very recently patented is sodium dichloroisocyanurate.

In the third part (Part 5 of the thesis), a low temperature combined scouring/bleaching process for two different varieties of desized, polyester/cotton blend fabrics (48/52 and 67/33) has been worked out using sodium dichloroisocyanurate activated sodium chlorite. The effect of process parameters namely, bleaching agent concentration, activator concentration and treatment temperature on whiteness index of the treated fabrics have been investigated using a response surface methodology. Since the best fitted regression equation is of a third order polynomial, the canonical optimisation is not possible. Hence the optimisation has been carried out by penalty function method. By this method, the optimum treatment conditions can be obtained within the feasible region and the other advantage of penalty function optimisation is that, the function itself can be taken as a constraint. The program developed has been run on the ICL 2960 mainframe computer to obtain the most economic recipe.

The kinetics of decomposition of sodium chlorite in presence of sodium dichloroisocyanurate has been investigated and it seems to follow first order reaction kinetics. The activator is susceptible to hydrolysis at room temperature (20-30 °C). On hydrolysis, hydrochloric acid is liberated. The liberated hydrochloric acid causes quaternisation of nitrogen atom, which increases its electrophilic character and hence accelerates the hydrolysis. The reaction is thus autocatalytic. During the course of hydrolysis, the first chlorine atom reacts at lower temperature and the second chlorine atom is replaced at or above 60°C, which has been substantiated by higher rate constants.

In the fourth part of the present study (Part 6 of the thesis), a recipe for combined scouring/bleaching of polyester/cotton blended fabric has been worked out using a foamed scouring/bleaching composition. The foam padded fabrics were processed in a laboratory model Vaporloc machine.

The fabric selected for investigation is a desized polyester/cotton 67/33 blend. For this process, a composition was prepared by emulsifying nonylphenol 10 EO condensate (non-ionic emulsifier), perchloroethylene, sodium chlorite and formic acid together. This composition was then converted into a foam with a derivative of sodium lauryl sulphate (SLS) based foaming agent and applied onto the fabric in a vertical mangle. The padded fabric was steamed in a laboratory model Vaporloc machine for different time periods to achieve required whiteness.

The effect of three process variables namely, bleaching agent concentration, residence time inside pressure chamber and treatment temperature upon whiteness index have been optimised by using Box and Behnkan response surface design methodology.

The salient features of the investigation have been summarised in the last part of the thesis (Part 7).

CONTENTS