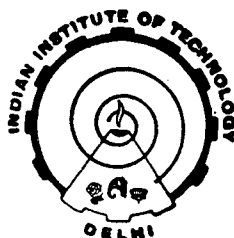


**SOME STUDIES ON THE ROLE OF AUXILIARIES IN THE
HIGH TEMPERATURE-HIGH PRESSURE DYEING
OF POLYESTER FIBRES**

by
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*A thesis submitted to the
Indian Institute of Technology, Delhi
for the award of the degree of
DOCTOR OF PHILOSOPHY*



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CERTIFICATE

This is to certify that the thesis entitled "SOME STUDIES ON THE ROLE OF AUXILIARIES IN THE HIGH TEMPERATURE-HIGH PRESSURE DYEING OF POLYESTER FIBRES" being submitted by Mr. D. Dhara, 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. D. Dhara has worked with my guidance and supervision and has fulfilled all the requirements for the submission of the thesis.

The results obtained 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

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Polyester fibre has come to stay as the most prominent fibre of the century. It is an invaluable fibre for the apparel as well as the industrial textile manufacture. Initially, many problems were encountered in developing a suitable method for dyeing of this fibre. To that extent, it was considered as a problem fibre.

Over the period, significant changes have taken place in the dyeing processes, namely, (a) Carrier dyeing, (b) High temperature-high pressure (HT-HP) dyeing and (c) Thermosol dyeing have been specifically developed for the dyeing of this fibre. These dyeing processes are now so well perfected that it is possible to dye all hues to any desired depth - light to dark, even jet black - with great ease. Efforts are on to optimize the quanta of inputs to achieve the most cost-effective results. For optimized dyeing, new dyes are being evolved, new machines have been developed and more efficient dyeing auxiliaries are being worked out.

A large metreage of polyester fibre-fabric is being dyed in the HT-HP dyeing equipment, since very efficient rapid dyeing machines are now easily available. In the rapid dyeing process, the total dyeing time has been considerably reduced, with the result, a very little time is available for levelling. To overcome this limitation, various types of levelling agents are being

used. These agents can be classified into two broad categories, namely, (a) surfactant type levelling agents and (b) carrier type levelling agents. It has been postulated that the surfactant type of levelling agents have a strong solubilizing power for the dye; with the result, they retard the dye uptake in the initial phase (during sorption stage) of dyeing and promote gradual and uniform dye sorption. On the other hand, use of carrier type levelling agents accelerate the dye sorption during initial stages of dyeing and affect the levelling of the dye by dye migration at the later stages of dyeing.

Although these compounds are being used for quite some time, the mechanism by which these additives act during dyeing has not been established clearly. In fact, there are a number of contradictions reported regarding their influence on dyeing.

In the dyebath the dye remains in three states, namely, (a) solid particle state, (b) molecularly dispersed or solubilized state and (c) adsorbed state. The first two are in the aqueous phase and the last one is in the fibre phase. Dye cannot go from solid particle state to adsorbed state directly. Hence addition of dispersing agents into the bath promotes the dye to go into the solubilized state. This eventually prompts adsorption onto the fibre phase. On the other hand, further increase of the dye solubility by subsequent addition of surfactants tends to retain the dye in the dyebath and thus retards dyeing process.

Carriers, were initially introduced as dyeing accelerators. Subsequently these compounds were also found to be excellent

levelling agents, at HT-HP dyeing conditions. They may also be used for the partial stripping of dyed materials, when the dyeings are too full. To obtain maximum stripping action, both the concentration of carrier and temperature of application are important. The concentration of carrier is generally higher than that normally used during dyeing. Carriers, having a capacity to solubilize the dye act as far more effective levelling agents for disperse dyeing in the HT-HP dyeing of polyester fibres than the nonionic surfactant type levelling agents, chiefly due to the plasticization effect of the former on the fibres.

The present study was undertaken to explain the action of auxiliary chemicals during HT-HP dyeing of polyester fibres. For this purpose two basic types of additives were chosen: (a) carrier type and (b) nonionic surfactant type. In the first category, phenol was chosen as the representative. In the second category, four nonionic surfactants, viz., polyethylene glycol-mono- and -di-laurate (PGL1 and PGL2) and -mono- and -di-oleate (PGO1 and PGO2) were synthesized and used.

The influence of these additives during HT-HP dyeing of polyester fibre was studied using a Second Order Response Surface Design Technique. According to this technique, a 4-factor-5-level experimental design scheme needs only 31 experiments to be carried out, instead of all 625 possible experimental combinations. The experimental response values of these 31 experiments were used to workout a regression equation.

In order to find out significant coefficients, regression

analysis was carried out by two methods. In one method, weightage is given to all 31 experimental response values, while in the other method stress is on the repeat experiments. The regression coefficients, calculated by the former method were utilized for predicting the response values of all 625 experimental combinations. These values were used finally to explain the behaviour of the dyebath additives.

The salient features of the present investigation can be summarized into the following points:

- (a) Use of Second Order Response Surface Design Technique is a useful tool in investigating the influence of different types dyebath additives on dyeing. This methodology is capable of predicting the response values of most dyeing experiments.
- (b) Both phenol and PGFA products are capable of solubilizing the dye. The extent of dye solubilization increases with increase of temperature.
- (c) Most of the dye additives (except PGL2) under the present investigation, are capable of accelerating dyeing operation at 100°C.
- (d) At 130°C, only phenol is capable of accelerating dyeing among all the five additives, though the extent of influence is lower than that at 100°C.
- (e) PGFA products, in general, (except PGL2) retard the dyeing operation at 130°C.
- (f) Shade % has a significant influence on the accelerating effect particularly at 100°C as has been observed both in the

case of phenol and PGFA products. Higher the shade % more is the accelerating effect. However, both PGO1 and PGO2 show slight retarding effect at lower shade %.

(g) Phenol accelerates dyeing by virtue of plasticization of the fibre as well as by increasing dye solubility.

(h) The dye solubilizing capacity of the PGFA products is responsible for the accelerating effect at 100°C.

(i) Retarding effect of PGFA products at 130° C is related to the retention of the dye in the surfactant layer, which is separated at the dyeing temperature, due to the relatively low, cloud point of these products.

(j) Nonionic additives, in general (except PGL2) show similarity in behaviour. However, when compared among themselves some difference of behaviour is discerned.

(k) PGL2 fails to show any significant influence on dyeing action under the investigated experimental conditions.

(l) PGFA products in general, show better migration of the dye as compared with phenol, when used in equimolar concentrations.

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