SOME ASPECTS OF ENZYMATIC TREATMENT OF COTTON

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Abstract

Enzymes are protein products which are most stable at their isoelectric point (zwitterion). At higher pH values enzymes ionize as weak acids and are precipitated by cationic inhibitors. At lower pH values they ionize as weak bases and are precipitated by anionic inhibitors. Enzymes have three dimensional shapes with the following configurations: alpha helix design, beta pleated sheets, and hairpin turns. They are used in food and beverage processing, medical and pharmaceutical applications, and in textile processing operations. The enzyme, amylase, that is specific for hydrolyzing starch, has been used for a very long time for desizing starch sized cotton warp yarns of woven fabrics. More recently enzymes have been investigated for replacement of harsher chemicals used in some textile operations, such as for bio-polishing and bio-stoning of fabrics in garment form. In the latter operation enzymes have replaced the pumice stones which were used to soften garments and to remove surface color for obtaining the washed-down appearance on garments.

A number of scientists are engaged in research on the use of enzymes for scouring and bleaching fabrics also, but these areas will no doubt require the use of several different types to achieve success. Whether or not such endeavors will be fully successful remains to be determined. In some cases a combination of enzymatic and conventional treatments may be required to achieve the desired results.

The enzyme that is most useful for hydrolyzing cellulose is cellulase. Hydrolysis occurs at the β-1,4 linkages of the cellulose chain. The whole enzyme from the fermentation process consists of three active components: exo-cellobiohydrolase, endo-1,4-β-glucanase, and cellobiase. The latter ultimately breaks down cellobiose to glucose. The catalytic reaction rate is dependent on the temperature and pH of the treating solution, and the enzyme concentration. The hydrolysis reaction is also influenced by the type of chemical modification of the substrate and the condition of the substrate with respect to the presence of specific additives and/or dyes. Enzymic hydrolysis was found to be reduced substantially after cotton fabric was chemically modified by crosslinking with a methylolamide or polycarboxylic acid crosslinking agent, such as dimethyloldihydroxyethylene or 1,2.3.4-butanetetracarboxylic acid. The reason for this is that crosslinking of cellulose reduces enzyme accessibility to the cellulose chain linkages where bond cleavage would normally occur. Certain dyes may inhibit enzyme activity in a similar manner also, but more research is required before definitive conclusions can be made beyond the scope of this presentation.

In this study the influences of some specific direct and reactive dyes were determined, based on breaking strength retention of the fabrics and analysis of white specks or neps on the dyed fabrics. Of the direct and reactive dyes used there was not a great deal of difference between breaking strength retention values for those fabric that were enzyme treated either before of after dyeing. Much more obvious were the effects of enzyme treatment on the appearance of white specks on the dyed fabrics. The enzyme treatment was effective in reduction of cotton neps which manifested themselves as white specks on the dyed cotton substrate. In all cases both the total number and area of white specks were lower on those of fabrics that were enzyme treated and then dyed compared to fabrics that were dyed first and then enzyme treated. These quantitative evaluations were obtained by means of an image analyzer system. The results suggest that specific dyes on the cotton substrate may indeed reduce enzymic hydrolysis to some degree. This is important from the standpoint that in modern laundry detergents cellulase enzymes are present for the purpose of bio-polishing fabric surfaces to remove protruding fibers, thereby enhancing surface appearance and restoring color brightness. If some fabrics contain dyes that retard enzymatic action, the potential benefits of the detergent containing enzymes will be diminished. Addition research in this area is in progress.

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