



BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Department of Plastics and Rubber Technology

Ph.D. THESIS

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Bioscouring of Cotton Fabrics

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1. INTRODUCTION

Preparation and bleaching are among the most energy- and chemical intensive steps of the conventional cotton finishing. About 75 % of the organic pollutants arising from textile finishing are derived from preparation of cotton goods. In the conventional preparatory process concentrated sodium hydroxide solution and additional hydrogen peroxide and/or sodium hypochlorite solutions are applied for removing the impurities from raw cotton. Cotton fibres contain approximately 10 % by weight of non-cellulosic substances, such as waxes, fats, pectins, proteins, non-cellulosic polysaccharides, water-soluble inorganics, lignin-containing impurities and colouring materials. Most of them are located in the outer layer of the fibre. By removing the impurities, the preparatory process yields an adequately absorbent and appropriately white material with cellulose content of 99 %, but the process generated huge amount of effluent. On the fibre level, oxidative damage may occur and be reflected in a lower degree of polymerisation and decreased tensile strength.

Biopreparation may be a valuable and environmentally friendly alternative to harsh alkaline chemicals for preparing of cotton. In bioscouring the removal of the non-cellulosic substances can be achieved mainly by hydrolytic enzymes, such as pectinases, xylanases and cellulases. The bioprocess has several advantages over conventional chemical scouring. Enzymes operate under mild conditions (pH, temperature) with low water consumption and act only on specific substrates.

Numerous studies have been carried out on biopreparation of cotton in the preceding 3-4 years. The results clearly show that in bioscouring of cotton, degradation of pectic substances is one of the most essential processes. Enzymatic degradation of pectin accelerates the removal of waxy materials from the cotton primary wall, thus produces water wettable cotton. However, the degree of whiteness is often less and the process is not suitable for removing of seed-coat fragments and mote adequately. By now it is also clear that the greatest obstacle to commercialisation of biopreparation is the removal of matter (stalks, leaves and seed-coat fragments) of vegetable origin.

In spite of the extensive information available and the large number of papers published, numerous questions have remained open concerning the properties of bioscoured cotton substrates generally and the degradation of pectin and seed-coat fragments particularly. It became clear soon that if we intend to explain certain phenomena, help process development or contribute to the solution of problems emerging in the practice, we have to concentrate on the basic problem of cotton bioscouring. As a consequence, the main goal of this thesis is to carry out detailed studies on certain aspects of the degradation of pectin and seed-coat fragments.

Desized cotton fabric was treated with different commercial enzymes under a wide range of conditions, and the wettability, whiteness, colour evenness and weight loss were studied. Effect of complexing agent on the efficiency of the process was also determined. Attempts were made for determination of the role of complexing agents in the degradation of pectin. In a further step degradation of seed-coat fragment was investi-

gated in details. Fabrics subsequent to biopreparation are generally further subjected to bleaching, dyeing or printing. Therefore, it was particularly essential to characterise the bleachability and dyeing properties of the biopretreated substrates. The results were compared with those obtained in a conventional alkaline scouring.

2. MATERIALS AND METHODS

Greige cotton print cloth fabric and spinning blowroom waste (cotton seed-coat fragments) were used for the tests. 100 per cent greige linen fabric was also tested as an additional substrate for studying the effect of ethylenediaminetetraacetic acid (EDTA) chelator on the pectin degradation in bioscouring. The applied enzymes were an acidic cellulase (Celluclast 1.5 L, *Trichoderma reesei* origin), an acidic pectinase (Viscozyme 120 L, *Aspergillus sp.* origin) and a pure xylanase (Pulpzyme HC, *Bacillus sp.* origin). The enzyme activities were measured by internationally recognised methods.

Enzymatic treatments were carried out at pH 5.0 for the enzymes Celluclast 1.5L and Viscozyme 120L, or at pH 7.0 for the enzyme Pulpzyme HC; enzyme concentration of 1-4 g/l; treatment time of 1 h; incubation temperature of 50 °C; and a nonionic surfactant concentration of 1 g/l. When the effect of the chelating agent was tested, EDTA was added to the enzyme solution. The role of EDTA was also investigated. Caustic scouring was performed with 50 g/l sodium hydroxide solution and the hydrogen peroxide bleaching was carried out with a bleaching solution

contained 2 ml/l of 30 % hydrogen peroxide. For dyeing, a heterobifunctional reactive dye was used in a bath exhaustion procedure.

Weight loss of the substrates was determined by weighing the samples before and after the treatment following 24 h of conditioning at 20 °C and 65 % rh. Release of reducing sugars during the enzymatic treatments was determined in the reaction liquor using the 3,5-dinitrosalicylic acid reagent. Fabric wettability was determined by water dropping test. The colour evaluation was done according to the CIELab colour space. Colour evenness of the treated fabrics and fastness to washing of the dyed samples were also investigated. The metal ion content of the substrates and the enzymes was determined by inductively coupled plasma optical emission method (ICP-OES).

3. NEW SCIENTIFIC RESULTS

1. Besides cellulases and pectinases, xylanase enzyme can also be used effectively in biopreparation of cotton fabric. Biopretreatment results in a hydrophilic and homogeneously absorbent fabric with excellent colour evenness.
2. Whiteness of the biopretreated fabrics is less than that of the conventionally scoured sample. However, a hydrogen peroxide bleaching applied subsequent to the biopretreatment overcomes the colour differences between conventionally scoured and bioscoured samples. Hydrogen peroxide bleaching does not cause divergences and perceptible colour differences in the samples.

3. Biopretreated fabrics can be dyed with a reactive dye subsequent to the enzyme treatment without further oxidative bleaching. At higher dye concentrations, there is no perceptible colour difference between the biopretreated and alkaline scoured fabrics in dyed state. In pale and medium dyeing, however, the colour difference is great and perceptible. Bleaching applied subsequent to bioscouring significantly decreases the colour difference between the dyed samples pretreated in different ways.

4. Efficiency of the biopreparation process can be enhanced significantly by adding ethylenediaminetetraacetic acid chelator to the enzyme solution. EDTA accelerates the degradation of cotton seed-coat fragments, the most resistant impurities of cotton. Furthermore, EDTA improves the lightening and weakens the darkening effects of the enzyme treatments carried out in acidic or neutral medium, respectively.

5. Results on 'enzyme-EDTA-substrate' interaction investigated in biopreparation of cotton and linen prove that application of EDTA in different concentrations does not inhibit the main activities of the hydrolytic enzymes (pectinase, xylanase), but does not increase them either. EDTA modifies the substrate structure by removing the calcium ions from the cross-bridges, linked the macromolecules in pectin.

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