Improving Dimensional Stability of Cotton Fabrics with Cellulase Enzymes

May 23, 2001

Dear Sir:

Cellulase enzymes are a commercial success, with finishing effects such as depilling and defuzzing of fabrics or the aged look after washing of garments. The major reason for this success is the slow kinetics of enzymatic degradation due to the crystalline nature of cotton cellulose. The molecular size of any cellulase enzyme is in the range 20–80 kDa, which prevents their diffusion inside the fibers, since the cellulose chains are a tightly packed hydrogen-bonded structure. Therefore cellulase treatments are restricted to the fiber surface, with minimal degradation [1–3].

Cellulases are a complex mixture of endo (EG, endoglucanase) and exo (CBH, cellobiohydrolases) enzyme types [1–3]. The enzymatic hydrolysis of cellulose proceeds in an "onion peeling fashion," removing layer by layer. EGs with no CBH activities have limited action at the fiber surface, since only the most accessible and external glycosidic bonds are hydrolyzed [1–3]. CBHs have a slow action by means of cellobiose scission at the chain ends. However, with mechanical agitation, new cellulosic surfaces are created and new sites for EG are generated. This cooperative action can create microfibrils at the fiber surface in a smooth fiber during the early stages of a treatment, which are later removed. However, these mechanisms, which are the basis of known commercial treatments, are not yet fully understood [1–3].

We have made tentative attempts to understand what cellulases do to cellulosic fibers [2, 3], measuring the crystalinity index, SEM (scanning electron microscopy), moisture regain, and dye affinities. SEM photos revealed fiber damage but without significant changes in other properties. Cellulase led to a change in the reducing sugars on the cotton surface, indicating broken cellulosic chains. Changes in the external broken chains are expected to change the collapsing-twisting behavior of cotton fibers in a drying process. It is known that wet cotton fibers have more cylindrical shapes and the fibers collapse and twist during a drying process [4]. The collapsing-twisting behavior is due to the loss of water and hydrogen-bond forming interchains, thus saving space. If some of the external chains are broken or loose, the driving force to save space is lower and the collapsing-twisting behavior should decrease.

To observe if this is really the case, we immersed fibers (3 g) in 3% *T. reesei* cellulase crude solutions (from Primalco, Finland) at pH 5 in 0.1 *M* acetate buffer (150 ml) for 3 days at room temperature. A control treatment involved buffer only. The measured weight loss was about 12%, and we verified an increase in cotton reducing ends from 0.2 to 0.4 mg glucose per gram of cellulose [1]. Cotton samples were boiled in distilled water, never dried, and used for environmental scanning electron microscopy (ESEM) analysis. ESEM is similar to SEM, but the pressure in the sample chamber can be controlled and varied in such a way that the level of water in the samples can be regulated.

Figures 1a and b show the drying process of the control and cellulase treated cotton fibers, respectively. The cellulase damaged fiber shows lower collapsing-twisting behavior when compared to the untreated control fiber, confirming our suggested mechanism. It appears that the broken ends induced by cellulase treatment

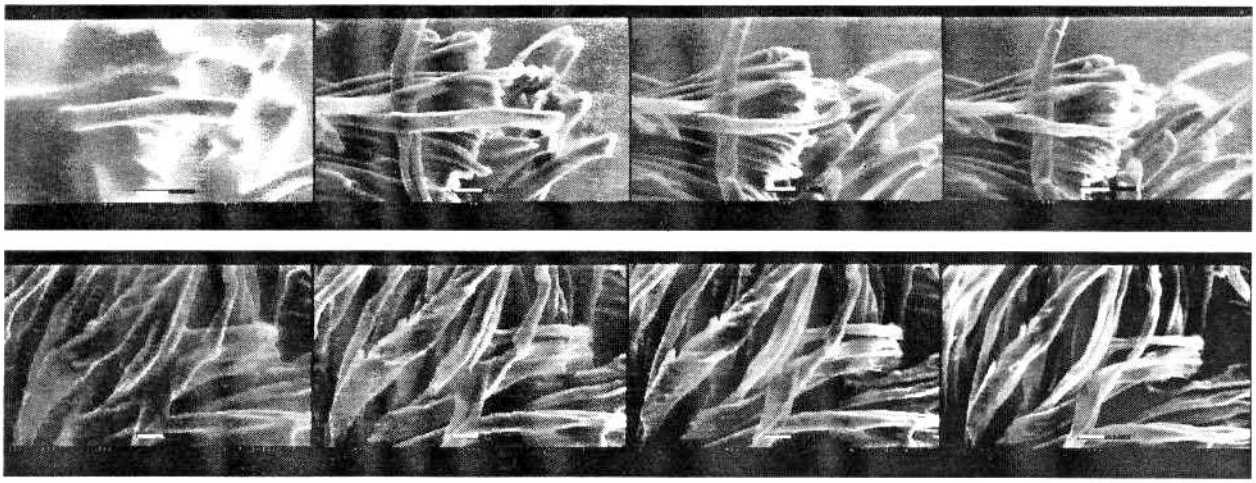

FIGURE 1. ESEM shots of sequential drying moments of (a, top) untreated fibers and (b, bottom) cellulase treated fibers.

can lower the tension, thereby reducing fiber collapsing-twisting during drying.

These findings may have important implications in textile processing, since the dimensional stability of cotton fabrics is strongly affected by their drying behavior, especially in cotton knits. Therefore, a controlled treatment can considerably reduce fiber collapsing-twisting during drying and rewetting and improve the dimensional stability of cotton fabrics. To confirm this expectation, we padded a cotton jersey fabric with 10% cellulase solution in 0.1 *M* acetate buffer at 120% pick-up and allowed it to react for 3 days at room temperature, along with a suitable control. Both fabrics were rinsed and subjected to an ISO 6330 standard washing test.

We confirmed our expectations, seeing an improvement in dimensional stability from −10% (control) to −3% (cellulase treated) after a standard washing test. All experiments were done in triplicate with a 1% standard deviation. These findings open possibilities for the first treatments using cellulases in padding processes with no mechanical agitation. The improved dimensional stability of cotton fabrics could possibly be added to the list of beneficial effects of enzymes on textiles.

LITERATURE CITED

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