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Ink jet printing of bio-treated linen, polyester fabrics and their blend

H.M. El-Hennawi, A.A. Shahin*, M. Rekaby, A.A. Ragheb

National Research Centre, Textile Research Division, El-Behouth Str., Dokki, Cairo, Egypt

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ABSTRACT

Cellulosic fabrics were surface modified using Brewer's yeast filtrate and cellulase enzymes (Valumax A828, Valumax A356) to enhance its affinity to ink jet printing. The effect of enzymes on the surface structure and morphology of the cellulosic fabrics used has been illustrated using scanning electron microscope. Related test as tensile strength have been measured. The bio-treated cellulosic fabrics were digitally printed and the colour strength (K/S) and % increase in K/S were measured. Effect of different conditions (enzyme concentration, temperature and time) was investigated to obtain the optimum condition of each enzyme for each fabric that or which was indicated by higher colour strength. Results show a noticeable increase in the K/S especially for cellulosic linen and its blend compared to the standard samples. The optimum conditions to obtain the higher K/S by using Brewer's yeast filtrate and the other two cellulase enzymes in the pre-treatment of ink jet samples were obtained.

1. Introduction

Recently, there has been an increasing interest in the application of ink-jet printing for textile applications. The technique of ink-jet printing offers benefits such as speed, flexibility, creativity, cleanliness, competitiveness and eco-friendliness (Gupta, 2001; Kan, Yuen, Ku, & Choi, 2005; van Parys, 2002). In conventional textile printing, dyes are applied along with the printing chemicals in the form of a printing paste. However, due to the requirements of ink purity and specific conductivity for the digital ink-jet printing (Aston, Provost, & Masselink, 1993; Schulz, 2002; Siemensmeyer, Siegel, Ervine, & Bullock, 1999), none of the conventional printing chemicals such as alkali, urea and sodium alginate can be directly incorporated into the ink formulation and therefore a printing medium should be prepared for textile digital ink-jet printing (Aston et al., 1993; Choi et al., 2005; Kan, Yuen, Tsoi, & Chan, 2011). Inks for fabric printing are usually classified into two categories of dye-based and pigment-based inks. Pigment-based ink printing shows better water fastness and light fastness of the fabric than dye-based ink printing. It saves water and energy, and the most important thing is that it is environmentally friendly.

Polyester is one of the most important textile materials in ink jet printing since it has a lot of special characteristics, such as superior strength and resilience. But the molecular part of poly(ethylene terephthalate) (PET) lacks polar groups, which causes it to have low surface-energy and poor wettability (Yuen, Ku, Kan, & Choi, 2007). When polyester fabric is printed with pigment-based inks, the printed patterns will have poor colour yield and may bleed easily, especially for thin fabric. Thus, the pre-treatment process is necessary for polyester fabric ink jet printing. On the other hand, linen, which is a natural bast fibre, has unparalleled characteristics such as a feel of freshness and a magnificent brilliance. It is very hygienic and it imparts an air of satisfaction and style to the wearer (Behera, 2007). With the trend of fashion towards natural, comfortable yet elegant fabrics, linen and linen-blended fabrics have gained prestige and increased reputation. The objective of our work is to improve the colour parameter of ink jet printing polyester and linen fabrics and their blend using eco-friendly method by applying different enzymes.

2. Experimental

2.1. Materials and reagents

2.1.1. Fabrics

- Semi finished cellulosic linen fabrics supplied by Textile Industries Egyptian Co. Ointex, Egypt.
- Polyester (PE) knitted fabric of 150 g/m^2 supplied by a private sector company.
- Linen/polyester blend 50/50 supplied by Textile Industries Egyptian Co. Ointex, Egypt.

* Corresponding author.
E-mail address: asmaashahine30@yahoo.com (A.A. Shahin).

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2.1.2. Enzymes and yeast

The following two different commercial enzymes and Brewer yeast were used:

(a) Valumax® A828 from *Aspergillus oryzae* was supplied by Novozymes, Denmark, of declared activity 2000 ECU/g; Cellulase Unit per gram.
(b) Valumax® A356 was purchased from Novozymes, Denmark: its declared activity 120 CVU/g; Combi Cellulase Units per gram. It is produced by submerged fermentation of genetically modified microorganisms.
(c) Locally available Brewer's yeast was also used.

2.2. Methods

2.2.1. Scouring

Before using, the fabrics were washed with a solution containing 1 g/l non-ionic detergent at 70 °C for 1/2 h. Then they were washed, and air dried at room temperature.

2.2.2. Preparation of Brewer's yeast filtrate

The suspension of active yeast was prepared according to a reported method (Marie, El-Hamid, El-Khatib, & El-Gamal, 2004). The procedure was adopted as follows.

450 g dry weight of Brewer's yeast was pasted with 150 g sugar, and then 1 L of warm water (40 °C) was added to the paste of yeast while stirring for a period of time until the yeast was brewed. Finally the solution was filtered and frozen.

2.2.3. Bioprinting of the applied fabrics (linen, polyester and their blend)

The fabric samples were first printed with a printing paste containing only the thickening agent and the enzyme (i.e. uncoloured paste). The recipe of the uncoloured printing paste was as follows:

Enzyme	X g
Sodium alginate	30 g
Water	Y g
Total	1000 g

Sodium alginate "thickening agent" was soaked in small amount of water overnight at room temperature before preparing the uncoloured printing paste. The enzymes used (50, 100, 200, 220, 240 and 260 g/kg) or Brewer's yeast filtrate (50, 100, 300, 600 and 900 ml/kg) was then added on the thickener suspension and the whole paste was adjusted to 1 kg with the addition of the necessary amount of water. The pH of the paste was adjusted according to the enzyme used and then the samples were printed and left in the oven for different intervals of time (60, 120, 180 and 240 min) and also at different degrees of temperatures (30, 40, 50, 60, 70 and 80 °C).

2.2.4. Ink jet printing of bio-printed fabric

The bio-printed linen, polyester and its blend samples were digitally printed with yellow pigment based ink by ink jet machine (inkjet plotter printer – mimaki) followed by air drying.

2.2.5. Fixation

The resist printed fabrics were fixed via thermo fixation at 150 °C for 5 min.

2.3. Analysis and measurements

2.3.1. Colour measurements

The colour strength (K/S) was measured by reflection spectroscopy with a Hunter Lab UltraScan PRO spectrophotometer according to a standard method (Judd & Wyszecki, 1975).

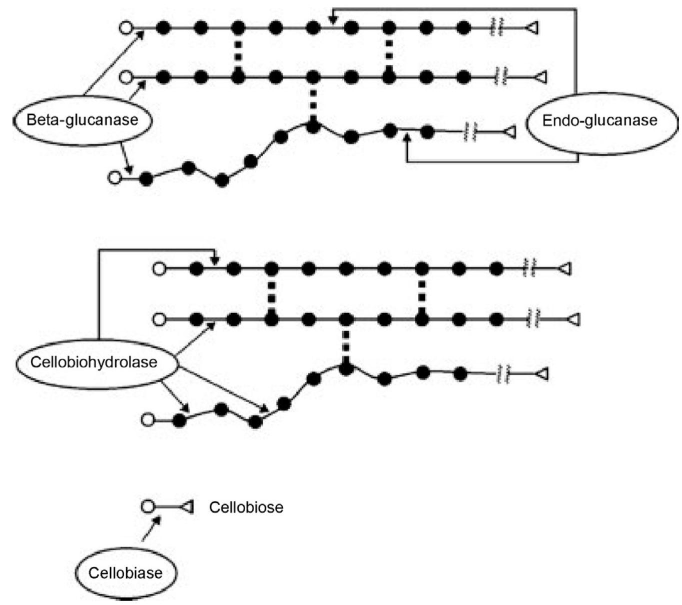

Fig. 1. Enzymatic reaction of cellulose by cellulase.

2.3.2. Tensile strength of fabric

The test was carried out according to the ASTM Standard Test method D 682 1924 on a tensile strength apparatus type FMCW 500 (Veb Thuringer Industries Work Rauenstein 11/2612 German) at 25 ± 2 °C and 60 ± 2% relative humidity (ASTM Standard C33 (ASTM D1682-64 e1), 1975).

2.3.3. Morphology study of the fabrics

The untreated and treated fabrics were analysed by scanning electron microscopy (SEM), Topcon-Microscope (ATB-55) to investigate morphological changes of the surface structure.

2.3.4. Determination of fastness properties

The treated samples were washed as per the conditions specified in the test AATCC test method (AATCC Test Method (36-1972), 68, 1993). The colour fastness to rubbing, perspiration and light were determined according to the AATCC test methods (AATCC Test Method (8-1989), 68, 1993; AATCC Test Method (15-1989), 68, 1993; AATCC Test Method (16A-1989), 68, 1993).

3. Results and discussion

Commercial enzyme treatments have usually target for cotton, however, there were limited reports on other cellulose fibres (Buschle-Diller, Zeronian, Pan, & Yoon, 1994; Pedersen, Screws, & Cedron, 1992). Thus one of the objectives of our work is to determine whether the previous findings for cotton pre-treatment with cellulase were valid for other cellulosic fabrics such as semi finished linen, linen/polyester blend and for non-cellulosic fibres such as polyester to be applied in inkjet printing. Cellulases are secreted by various fungi and bacteria as complex mixtures of three major kinds namely endoglucanase (EGs), exocellobiohydrolase (CBHs), and beta glucosidases. The proposed mechanism of cellulase action onto cellulose is illustrated in Fig. 1. Endoglucanase EGs hydrolyze cellulase that are/because they are randomly long the chains, preferentially the amorphous region. CBHs attack the chain ends and produce primarily cellobiose coupled with the binding domains associated with the enzyme. The cellobiose and any small chain oligomers produced by CBHs are then hydrolyzed by the third enzyme beta glucosidase into glucose (Kan, Yuen, Jiang, Tung, & Cheng, 2007). The biological analysis of Brewer's yeast (*Saccharomyces cerevisiae*)