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# Electron-beam modification of textile fabrics for hydrophilic finishing

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**Abstract**

A study has been made to modify different textile fabrics such as cotton, cotton/polyester blend and nylon-6 fabrics by surface coating with a constant thickness layer of 25 μm of aqueous solution of polyvinyl alcohol (PVA) and acrylic acid (AAc). Radiation curing of surface coating was accomplished by electron beam irradiation with a constant dose of 50 kGy. Parameters affecting hydrophilicity of cured coated fabrics, namely, presence or absence of cross-linking agent and concentration of AAc in coating solution, were investigated. Properties affiliated with hydrophilicity, specifically water uptake and weight loss, before and after several washing cycles were followed up. Crease recovery angle was determined. Considerable enhancement, in water uptake as well as crease recovery angle, has been attained with increasing AAc content in solution in case of nylon-6, followed by blends and then cotton. Moreover, dyeing properties for coated fabrics, with solution containing 4 wt.% AAc, has been tested by color difference method, for basic and reactive dyes. Relative increase in color strength has been achieved. The presence of cross-linking agent in coating solution played a significant role, specifically in case of dyeing properties. Morphology of coated fabrics was examined by scanning electron microscope (SEM), which indicated fastness and compatibility between coating and fabrics. Correlation between structure and obtained results was given.


*Keywords:* Polyvinyl alcohol; Acrylic acid; Hydrophilicity; Electron beam

## 1. Introduction

The increasing demand for highly absorbing materials in recent years indicates that this subject will be the topic of more research work in the future. Sorption and permeability of water and water vapour to improve the comfort and wear properties of textiles can be enhanced by increasing the hydrophilicity of nature and synthetic fibers. Several methods have been used for the introduction of some hydrophilic monomers such as the grafting of vinyl monomers to the textile to produce fibers with hydrophilic properties having a great important application in the

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textile industry [1]. In the last three decades the technique of electron beam irradiation has been used for curing of different coating formulation on textile fabrics. The choice of coating formulation is important for acquiring these textiles new desirable properties useful for the textile industry. Nylon fibers, with its relatively high degree of crystallinity of 65–85% [2], as well as polyesters of degree of crystallinity of 20–60% [3] are forming hydrophobic synthetic fabrics. Cotton, on the other hand, is highly hydrophilic natural fiber, despite the fact, that it is characterized also by its high degree of crystallinity of 60–80% [3]. Increasing hydrophilicity of polyester has been accomplished by blending with cotton, but this way was not applied in case of nylon. Surface coating with suitable hydrophilic ingredient would represent a suitable way.

Polyvinyl alcohol, is a highly hydrophilic synthetic and easily available polymer. It suffers, however, from its poor water resistance and low mechanical strength. These shortcomings may be compensated by its transforming into insoluble and stable material through its cross-linking by different reagents such as aldehyde [4], dicarboxylic acid [5] or $H_3BO_5$ [6]. Also, heat [7] and radiation [8,9] have been applied in this respect.

In the present study, electron beam irradiation has been applied for modifying hydrophilic properties of cotton, cotton/polyester blends and nylon fabrics, using a coating solution of aqueous PVA containing acrylic acid, in presence or absence of cross-linking agent. Affiliated properties of modified fabrics as well as its dyeing characteristics have been followed up.

## 2. Experimental

### 2.1. Materials

The used fabrics were plain weave cotton and cotton/polyester blends of different ratios. They were kindly supplied by the Egyptian Company for Textile (Hosni and Bros.), Cairo, Egypt. Nylon-6 was supplied by El-Nasr Company for Weaving and Net Fabrics (El-Shorbagy), Cairo, Egypt. All these fabrics were scoured and bleached and were not subjected to any finishing processes. A laboratory grade acrylic acid monomer with purity 99% from Mercke company, Germany was used as received. The polyvinyl alcohol, laboratory grade used in this study was in the form of powder and had an average molecular weight ($M_w$) of 125,000, and was obtained from the Laboratory Rasayan, India. *N*,*N*-Methylene bisacrylamide (MBAM) from Aldrich, Wisconsin, USA, was used as a cross-linking agent. Two dyestuffs belonging to different classes were used throughout this work. These dyes are: Remacryl Blue (Basic dye) and Remazol Golden Orange (Reactive dye). The basic and reactive dyes were supplied by Hochest, Germany.

### 2.2. Coating preparation and irradiation

Films of PVA polymer were prepared by the casting solution technique. A known weight of PVA powder was dissolved in a known volume of distilled water at 95 °C. Two different coating formulations were prepared. Formulation I was first prepared by dissolving the required ratios of monomer (acrylic acid) in the aqueous PVA solution with continuous stirring, while formulation II is prepared by adding 0.2 wt.% of cross-linking agent to formulation I. These two formulations were then coated on the different fabrics with a floating knife coater with a thickness of 25 μm. The surface coated fabrics were exposed to accelerated electrons using the electron beam accelerator of 1.5 MeV and 25 kW made by High Voltage Engineering, USA, at National Center for Radiation Research and Technology, Cairo, Egypt. The required dose was obtained by adjusting the electron beam energy parameters and conveyor speed. The dose being used was 50 kGy.

### 2.3. Scanning electron microscope (SEM) measurements

The surface morphology of the different fabrics before and after surface coating was examined by SEM. The micrographs were taken with JSM-5400 instrument manufactured by Joel, Japan.

### 2.4. Water uptake measurements

Water uptake measurements were made by using coated and dried samples of known weights, which