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ELECTRON BEAM MODIFICATION OF POLYPROPYLEN FABRICS

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ABSTRACT

In this study, Electron bombardment with the energy of 10-40 Kev and different period of time has been carried out. Electron beam processing of polypropylene (PP) fabrics is found to promote significant changes in physical and chemical properties.
The obtained data show that, electron beam processing of PP fabrics allows an adjustable modification of their surface properties. The functional groups on the surface of samples were examined using FTIR spectrometer. Moreover, dyeing properties for treated fabrics has been tested. Relative increase in color strength has been achieved. Morphology of samples was examined by Scanning Electron Microscopy (SEM). The absorption times and contact angle were utilized to analyze the result of the treated samples.
This process is promising for the compatibilization of PP fiber and matrix with various compound in blends and production of multilayered composites for versatile applications such as laminates and supported compound.

1-Introduction

Polyolefines make up over 35% of all plastics production in the world. Polyethylene (PE) and Polypropylene (PP) are the only high volume polyolefines.[1]
PP is a thermoplastic with a number of desirable properties that makes it a versatile material. However, poor impact properties, especially at low temperature, limit some of its applications.
In view of its excellent engineering properties, such as resistance to chemical and physical abrasion, low friction coefficient, and high impact strength, PP has found a wide spectrum of application, particularly as a materials for prostheses in orthopedics [2, 9]
The development of methods for controllable modification of polymers in order to adjust their physicochemical, mechanical, optical and other properties without any chemical processing is one of the most important areas of polymer science and Technology. Modification of polymers is an important area of (Electron Beam) EB technologies providing an effective way to surface modification of various chemically inert materials such as polyethylene [3, 4]
Generally, two types of reaction exist with electron beam irradiation, which compete during radiation: chain linkage or breakage [5].
During the radiational modification of polyolefinic films, properties of their surface layer change. The layer oxidation is one of the most important processes that occur upon this treatment. This reaction depends significantly on the radiation dose [6, 7].
The radiation of polymeric materials with ionizing, radiation (gama rays, X-rays, accelerated electrons, ion beams and electron beams) leads to the formation of very reactive intermediates, free radicals, ions and excited states [8, 10].
In the present work, we studied the effect of electron beam irradiation on physical and chemical properties of PP fabrics.

2-Experimental:

Polypropylene plain-woven fabric with a fabric density of 20.1 ends/cm and 11.1 picks/cm were prepared from Yazd Baf Co, and used in all experiments. The fabric was weaved by 350.2 denier warp and 300.2 denier weft yarns. Before EB treatments, in order to minimize the chance of contamination, samples were washed with 1% nonionic detergent solution in 70^{0C} water for 15 min and then rinsed with water for another 15 min, and dried at room temperature

The samples were exposed to accelerated electrons using a laboratory electron beam accelerator made by Plasma Physics Research Center, Tehran, Iran, using a Hydrogen discharge through a concave cold cathode. The schematic view of the experimental setup is shown in Figure 1.

The experimental parameters were; pressure, 2.5×10^{-2} torr, electron current, 0.20-0.33 mA; electron energy, 10-15 keV and an exposure time of 5 seconds. The samples were bombarded with the electron gun at doses in the range of 10^{16} electron/cm^2. The specification of the samples is shown in Table 1. After electron irradiation, samples were dyed with basic dyestuff. A Varian, Cary 500 spectrophotometer was used to measure the optical properties of the dyed samples before and after electron irradiation.

The morphology of the bombarded samples was observed using a scanning electron microscope (SEM, LEO 440I). All the samples were coated with gold before SEM testing.

The functional groups on the surface of samples were examined using FTIR spectrometer (Bomem MB-100, made in Canada).

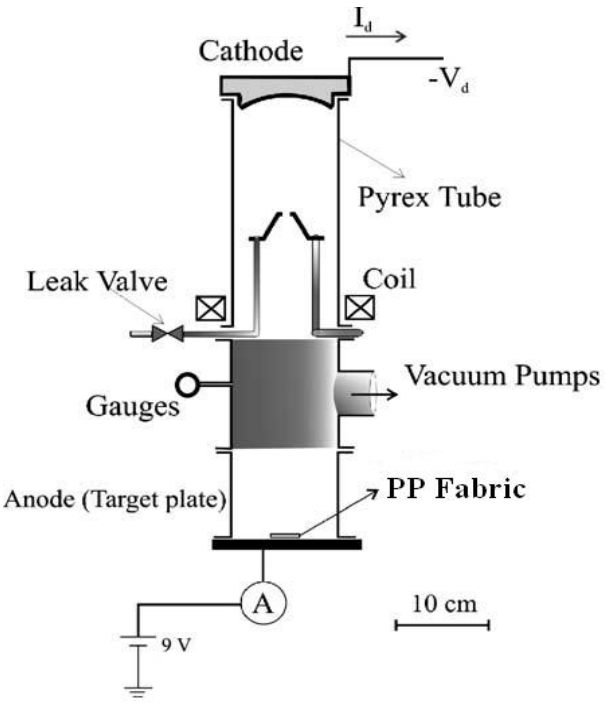

Figure 1: Schematic view of Electron Beam.

3-Result and Discussion:

3-1-FTIR

In function of the molecular structure of the polymer, one of the following events could proceed: cross-linking by free radicals, chain scission or radical stabilization. In the case of polymer treatments under hydrogen plasma conditions, plasma electrons are accelerated towards the exposed surface and lead to an increased reactivity of the respective surface. This fact is possible due to the breaking of the different bonds and further formation of free radicals. After the samples are brought out from the reactor, the reaction of the oxygen from the atmosphere with the free radicals takes place, and thus surface functionalization is obtained. This functionalization is more important for the materials that have no oxygen-containing groups in their initial composition (e.g. polyolefins). Upon exposure of PP fabrics to ionizing radiation (e.g. electron beams), new chromophore groups are generated, which efficiently absorb light from the UV, visible and infrared (IR) region of the spectrum. The main effects of an electron beam irradiation are; chain scission, oxidation and increase of unsaturation, depending on the dose rate and the oxygen content within the exposure environment.

FTIR was used to examine the functional groups of the corresponding samples investigated in Figure 2. As shown only a slight increase in absorbance at 1720 cm^{-1} (C=O) band and 3400 cm^{-1} (O-H) band after EB treatment can be noticed [11-14].

The improvement of wet ability properties confirmed that, electron beam treatment successfully activated the surface of PE samples by creating functional groups.

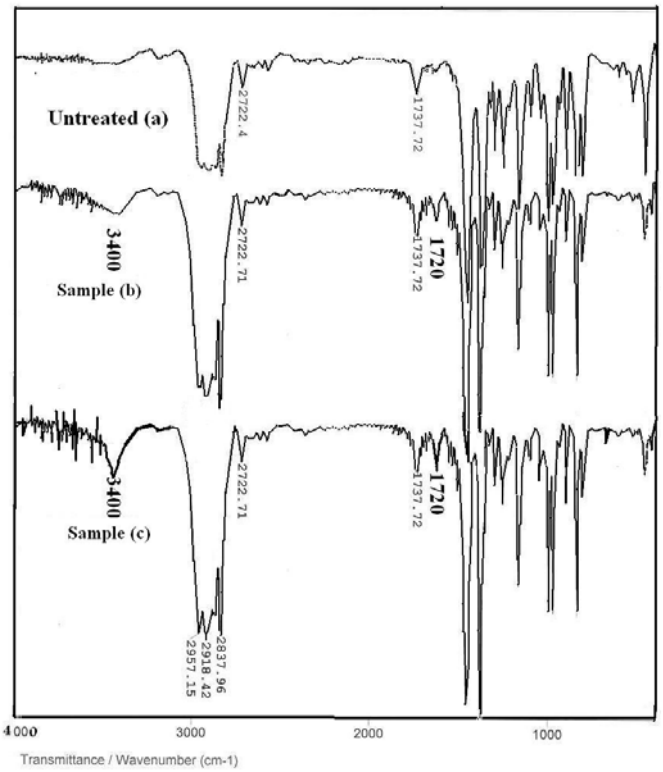

Figure 2: The FTIR spectra of Untreated (a), Dose of 4.4 $\times 10^{17}$ (b), Dose of 9.9×10^{17} (c).

3-2-Dye ability of PP fabrics:

The dye ability of hydrophobic fabrics, such as the PP fabrics we evaluated in this study, is very poor. It is known that introducing hydrophilic sites on the hydrophobic fabrics can improve the dye ability of these fibers.

EB modifications resulting in unsaturated bonds and /or free radicals on the surface of the fabrics have a significant influence on the overall surface changes and consequently on dye ability. As it illustrates in Figure 3, by increasing the dose of electron bombardment, the reflection factor is decreased, and this result indicate that by increasing the dose, the dye ability is increased. Also the important thing that should be considered is, by increasing more energy of bombardment, upper than dose of 9.9×10^{17}, samples are melted.

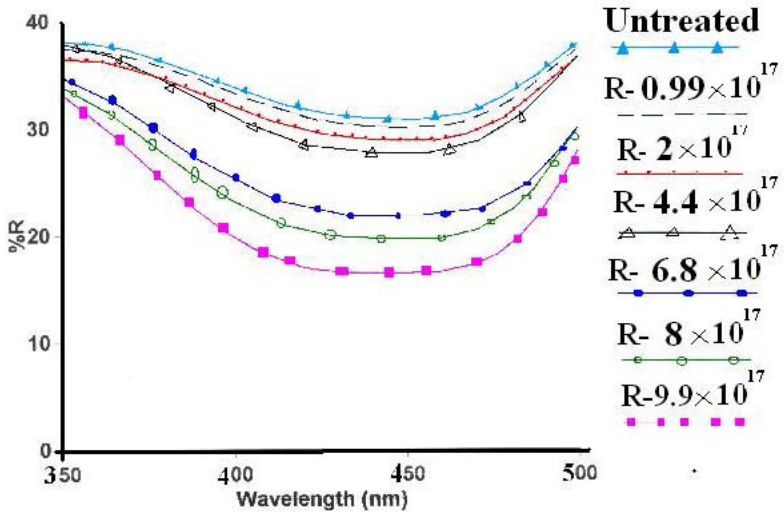

Figure 3: Reflective spectrophotometer of dyed samples.

3-3-Scanning Electron Microscopy:

Scanning Electron Microscopy (SEM) is the best known and most widely-used tool for surface analyses. As it can be seen in Figure 4, by increasing the dose of electron bombardment the surface of samples were rougher than untreated sample.

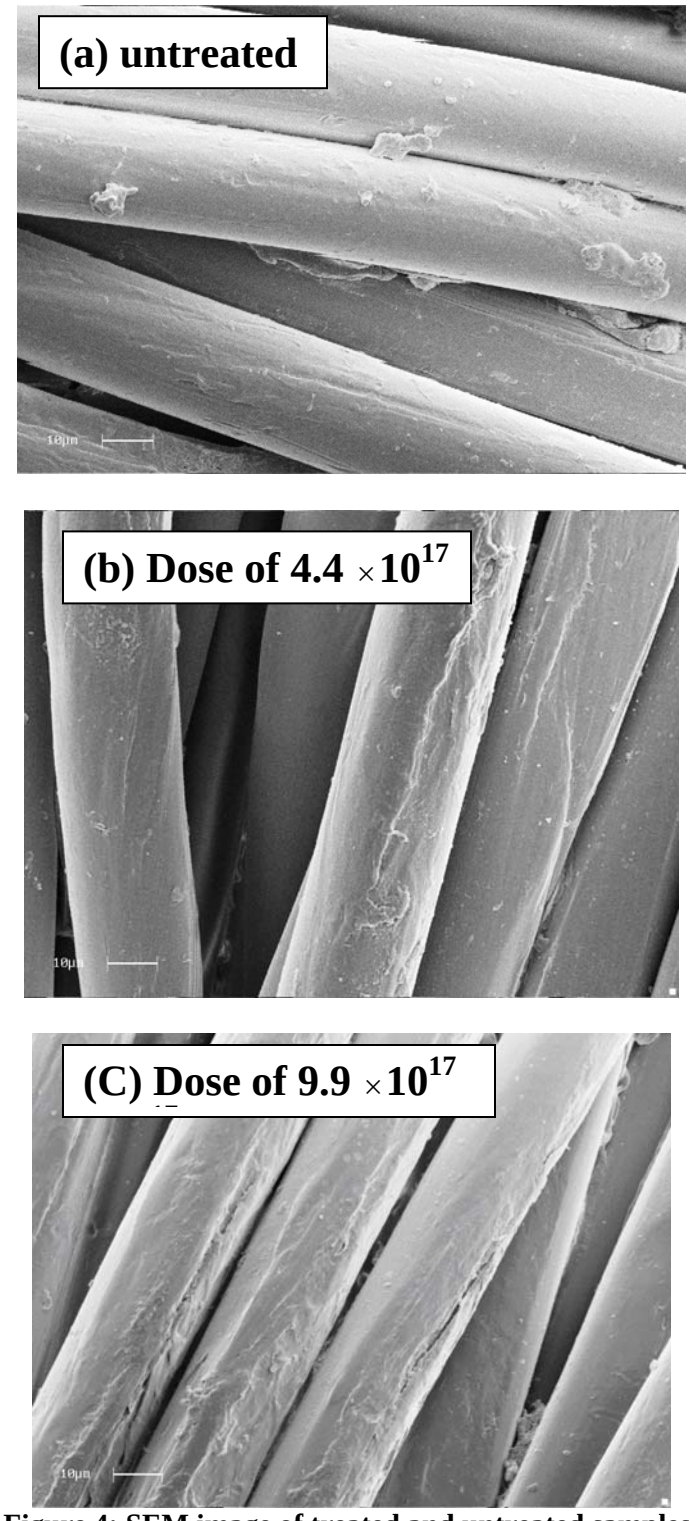

Figure 4: SEM image of treated and untreated samples.

Conclusion:

In this research work, the physical and chemical properties of PP fabrics were improved by using electron beam irradiation with different energy of bombardment.
By this treatment, the wet ability and Dye ability of PP were increased through creating (-O-H) and (C=O) groups on the surface of samples where hydrophobic properties changes to hydrophilic.
It is expected that, EB irradiation which has been known for a long time and is being used in different branches of industry, in the near future will conquer polymer as well.

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